Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Unlicensed Operation in the TV Broadcast Bands	)	ET Docket No. 04-186
	)	
	)	ET Docket No. 02-380
Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band	)	
	)	

To: The Commission

JOINT COMMENTS OF
THE ASSOCIATION FOR MAXIMUM SERVICE TELEVISION, INC.
AND THE NATIONAL ASSOCIATION OF BROADCASTERS

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EXECUTIVE SUMMARY

Over the next few years, consumers will spend billions of dollars in new digital receiving equipment, and the government will spend 1.5 billion dollars on a subsidy to fund digital to analog converter boxes. At a minimum, consumers will be replacing approximately 70 million television receivers that rely exclusively on over the air television reception. In addition, as the digital television world unfolds, new opportunities are emerging for over-the-air television broadcasting. New over-the-air mobile and portable devices and services are being developed. Advancements in transmission and distributed transmission systems are on the horizon. All of these investments, as well as the billions spent by broadcasters building the new digital television infrastructure, will be wasted if new DTV sets and other new DTV products and services receive interference from so called, "low power" TV band devices. In the digital world, interference causes the picture to become unwatchable.

The evidence presented in this proceeding, including research by the Canadian Research Centre Canada, as well as other leading experts demonstrate that the risk of co-channel, adjacent channel, out of band emission and other types of interference is significant. The existing Part 15 rules and the TV band device proposals to date will not protect consumers from interference.

Accordingly, the Association for Maximum Service Television, Inc. ("MSTV") and the National Association of Broadcasters ("NAB") hereby request the following:

- ***As the Commission has rightly decided, no TV band devices should be permitted to operate before the DTV transition.***

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- ***As the Commission tentatively concluded, any operation of TV band devices should be limited to fixed operations only. Personal and portable operations should not be permitted.***
- ***Protection of DTV operations should be based on Desired-to-Undesired (D/U) ratios.***

- ***To avoid interference to TV viewers, <u>all</u> TV band devices must operate outside the protected contour on both co- and adjacent channels. Such devices should not operate inside a stations contour on either the co-channel or first adjacent channels.***
- ***The sensing threshold proposed in the FNPRM does not provide adequate co-channel protection and misinterprets IEEE approach***
- ***The proposed out-of-band emission limits (Part 15.209) are inadequate to protect DTV viewers and must be amended.***
- ***The Commission must conduct testing to ensure that the final rules sufficiently protect television viewers. The Commission must enact a rigorous enforcement program***
- ***Any new devices allowed to operate in the broadcast spectrum should be exclusively licensed; no unlicensed operation should be allowed.***

MSTV and NAB understand the need to provide the opportunity for additional wireless broadband opportunities, especially in rural areas. We agree this goal can be accomplished without endangering millions of TV viewers and consumers. Nonetheless, the introduction of "low power" TV band devices, especially personal and portable devices, in the television broadcast band is an unprecedented spectrum sharing proposal which needs to be accompanied by proper testing. The protections adopted by the FCC should not threaten the success of the DTV transition. Only this way can the Commission guarantee that such devices do not harmfully interfere with existing licensed services in the band.

"TV band" devices must ensure that existing licensed operations are fully protected and the ability of TV broadcasters and other licensees to improve their operations and offer new services is not impeded.[4]

I. THROUGHOUT THIS PROCEEDING THE COMMISSION MUST UPHOLD ITS COMMITMENT TO THE DIGITAL TELEVISION TRANSITION.

The unprecedented spectrum sharing proposal at issue in this proceeding, whereby "TV band devices" may be allowed to transmit alongside the nation's broadcast television service, poses a significant risk of interference to the viewing public. These devices, although characterized by the FNPRM as "low power," may operate at power levels as high as 4 Watts – a power level which, for purposes of evaluating potential interference to television receivers or licensed wireless microphones, is by no means "low".[5] As the Commission considers adopting any rules authorizing such devices, it must be guided by its longstanding commitment to prevent interference to licensed services.[6]

Upholding that commitment to the viewing public has never been more important, as consumers are transitioning, *en masse*, to DTV. In the span of the next two years, consumers

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as wireless microphones used in program production and Electronic News Gathering ("ENG"). In the future, DTV promises to bring exciting new services to the American consumer, such as multiple high definition programming and mobile and portable television services.

[4] These comments use the term "TV band devices" to describe devices that may be allowed to operate in the television spectrum as a result of this proceeding. In this proceeding, the Commission has suggested that such devices could operate anywhere from 100 mW to 4 W.

[5] The Commission has proposed that TV band devices may operate at up to 4 Watts. This is considerably more, for example, than licensed wireless microphones, which may only operate with up to 250 mW under Part 74 of the rules. *See* 47 C.F.R. §74.861. It is also a much higher power level than other unlicensed devices, such as Broadband over Powerline ("BPL") devices, which are only permitted to operate at approximately .000000027 Watts using the suggested calculation contained in OET Bulletin No. 63 to convert 90 microvolts/meter field strength to power. *See* 47 C.F.R. §15.109.

[6] *See Unlicensed Operation in the TV Broadcast Bands*, Notice of Proposed Rulemaking, 19 FCC Rcd. 10018, 10019 ¶ 3 (2004) ("Initial White Spaces NPRM "); 47 C.F.R. § 15.5.

will purchase billions of dollars of new DTV equipment to continue to receive their local television services.[7] There are approximately 70 million television sets that rely exclusively on over-the-air transmissions and are not connected to cable or satellite services.[8] The Commission must make certain that these millions of television viewers, who will have spent a significant amount of money to receive digital television signals, are not adversely impacted by any TV band devices that may operate within the broadcast spectrum. Now is a particularly sensitive time in which to allow the unprecedented sharing of spectrum among licensed television services and "low power" TV band devices.

The stakes in this proceeding are especially high given that interference concerns are even more pronounced in the DTV context. As MSTV and NAB have previously explained, DTV is an all-or-nothing technology; interference means not just a degraded picture, but no picture at all.[9] If consumers are subjected to harmful interference from TV band devices, they will see a frozen picture or blank screen – in other words, a complete loss of over-the-air service.

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[7] In addition, the Commission must keep in mind the billions of dollars that broadcasters have and will have invested to build out their stations and infrastructure to bring DTV service to the public.

[8] Most significantly affected will be the 20 million households who rely solely on broadcasters' over-the-air signals. The Commission must not lose sight, however, of its obligation to protect the millions of cable and satellite households with one or more television sets that are not connected to the pay service. *See* Comments of NAB and MSTV, MB Docket No. 04-210 (filed Aug. 11, 2004); Comments of the Association of Public Television Stations, MB Docket No. 04-210 (filed Aug. 11, 2004) at 10 (estimating 34.5 million over-the-air sets in homes that also subscribe to cable or satellite); Comments of the Consumer Electronics Association, MB Docket No. 04-210 (filed Aug. 11, 2004) at 4 ("[E]ven in cable and/or satellite households, not every television in the household may be connected to these services. This reflects the household's conscious decision whether or not to connect"); Comments of Sinclair Broadcast Group, Inc., MB Docket No. 04-210 (filed Aug. 11, 2004) at 3 ("Approximately 33 percent of the respondents [to a survey conducted by Sinclair] live in households with at least one television that is used exclusively for free, over-the-air analog reception.).

[9] *See* Joint Comments of MSTV and NAB, ET Docket No. 02-380 (filed Jan. 27, 2003).

Further, as discussed below, once these TV band devices are in the hands of consumers, the Commission will have no effective means of policing interference.

While MSTV and NAB applaud the Commission's decision in the First R&O to keep TV band devices from operating in the broadcast spectrum until after the conclusion of the DTV transition, it is important to ensure that the public *continues* to experience the benefits of digital television technology well past the transition date of February 17, 2009.[10] With all the public and private resources invested over the past two decades, including the $1.5 billion appropriated by Congress for digital-to-analog converter boxes,[11] sacrificing the digital transition for speculative gains in unlicensed technologies would be a mistake. Years of hard work by broadcasters, government officials, consumer electronics manufacturers, and others have seen considerable progress. If TV band devices are allowed to interfere with digital television reception in 2009 or later, local consumers would lose out on the many public interest benefits of digital television, which the Commission has described to the public as "a new type of broadcasting technology that will transform television as we now know it."[12]

The FNPRM focuses on the traditional television model of a large tower transmitting a signal to a stationary television and fails to consider how the introduction of TV band devices could stunt the future development and improvement of new DTV technologies. The

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[10] That is, although the public may awake to excellent DTV reception in early 2009, if interfering devices are introduced into the spectrum, over time (and perhaps quite quickly) the ability of broadcasters to provide the public with the benefits of DTV, and improved coverage and reliability of that reception, will decline. Without carefully crafted interference protections, within just a few years or even months of the transition date, viewers experiencing seemingly inexplicable interference could begin returning newly acquired digital equipment and government-subsidized converter boxes.

[11] *See* Deficit Reduction Act of 2005, Pub. L. No. 109–171, §3005, 120 Stat. 4, 23 (2005).

[12] FCC, *Digital Television – Get It – Tomorrow's TV Today!*, FAQ, *available at http://www.dtv.gov/consumercorner.html*.

Commission is already considering, however, whether new technologies, such as Distributed Transmission Systems ("DTS"),[13] could improve the quality of service to local communities. Similarly, the industry, through ATSC, has adopted one new broadcast standard, and is in the process of evaluating additional standards to allow exciting new functionality, such as the broadcast of digital television signals to mobile and portable devices, including vehicular and pedestrian reception.[14] These are merely the first in what will certainly be a series of new DTV technological advancements.[15] Consequently, any rules the Commission creates to govern TV band devices must account for, and protect, these new evolving digital broadcast technologies and services.[16]

II. CERTAIN MINIMUM PROTECTIONS MUST BE ADOPTED BEFORE ALLOWING TV BAND DEVICES TO OPERATE IN THE BROADCAST SPECTRUM.

While MSTV and NAB continue to have concerns about the Commission allowing *any* TV band devices to operate in the spectrum, at a minimum, the Commission must ensure that its final rules incorporate the following principles:

- ***As the Commission has rightly decided, no TV band devices should be permitted to operate before the DTV transition.*** The interference potential for TV band devices operating in the spectrum will be at its highest during the digital transition. If consumers experience interference prior to the DTV transition, this will severely disrupt the effectiveness of the transition. The Commission should not do anything to undermine this important transition and therefore must not

[13] *See Digital Television Distributed Transmission System Technologies*, Clarification Order and Notice of Proposed Rulemaking, 20 FCC Rcd. 17797 (2005).

[14] Mark Richer, *Making DTV The Best That It Can Be*, TVNewsday, Jan. 25, 2007.

[15] For example, numerous devices are now available that permit the reception of DTV signals on laptop and personal computers.

[16] The Commission must also ensure that any new rules adopted in this proceeding do not inhibit the creation and protection of 175 new DTV allotments, as provided for in the Community Broadcasters Protection Act of 1999. *See* Community Broadcasters Protection Act of 1999, Pub. L. No. 106-113, § 1000(a)(9), 113 Stat. 1536 (1999).

waiver from its commitment to keep all new devices out of the spectrum at least until February 2009.

- ***MSTV and NAB agree with the Commission that any operation of TV band devices should be limited to fixed operations only.*** The Commission's cautious approach to permit only fixed low power TV band devices to operate in the broadcast spectrum is certainly a proper course of action. Personal/portable devices should not be allowed to operate in the television band until further study and testing. Given the unprecedented interference potential of these low power operations, it is important that the Commission first gain experience with the rules for fixed devices in this spectrum to ensure that those operations do not cause interference before allowing uncontrolled nomadic personal/portable devices to operate.

- ***Protection of DTV operations should be based on Desired-to-Undesired (D/U) ratios.*** In the initial *Notice of Proposed Rulemaking* ("NPRM"), the Commission correctly noted that "whether or not interference occurs depends on the desired to undesired signal ratio needed for acceptable service."[17] Any rules adopted for TV band devices must assure that appropriate D/U ratios are maintained to ensure that interference is not caused to TV viewers throughout the TV station service area. Such ratios should apply to *all* new TV band device operations in the band. Indeed, as discussed more fully below, although additional testing conducted by Communications Research Centre Canada ("CRC") on DTV receiver susceptibility generally supports use of those limits, it moreover suggests that interference protection considerations should also be given to second and third adjacent channels as well as to channels N+7, N+14 and N+15 and that further study on the impact of multiple interfering devices is needed.

- ***To avoid interference to TV viewers, <u>all</u> TV band devices must operate outside the protected contour on both co- and adjacent channels.*** To protect all TV viewers including those that receive a weak but acceptable DTV signal, a TV band device cannot operate on a co- or adjacent channel within the protected contour of a television station.[18] It should also be noted that a "weak" signal can be found anywhere within the TV service area, as occurs, for example, when the desired station's signal is blocked by terrain or buildings, or when the viewer uses an indoor antenna. Therefore, to ensure that the harmful interference is not caused to television reception, any TV band device must be located *outside* the television station contour, at a sufficient distance such that the required D/U protection criteria are always met.

- ***The sensing threshold proposed in the FNPRM does not provide adequate co-channel protection and misinterprets IEEE's approach.*** The sensing or

[17] Initial White Spaces NPRM at ¶ 30.

[18] Considering that a desired DTV signal of -83 dBm and above will produce a perfect picture and sound, and the D/U ratios which are necessary to protect television reception, TV band devices must operate outside the protected contour.

detection threshold level should be a function of the interference potential of the TV band device and should ensure that the TV band device is far enough away not to cause interference to television reception. In proposing a level of -116 dBm, the FNPRM failed to provide any analysis on how that level would provide such protection to viewers, citing only that the level was supported by the working group of IEEE 802.22 Wireless Society ("IEEE 802.22"). In fact, the FNPRM's proposal misunderstands IEEE 802.22's important proposal, which protects licensed services by absolutely barring operation within the television station's protected contour. To prevent such operation, IEEE 802.22 would employ sensing *in addition to* geolocation – specifically, GPS and professional installation requirements that guarantee that the new device stays a sufficient distance *outside* the protected contour of a TV station's co- and adjacent channel. IEEE 802.22's use of a -116 dBm sensing level is merely one piece of the mechanism necessary to protect the viewing public, not the whole solution.

- ***The proposed out-of-band emission limits are inadequate to protect DTV viewers and must be amended.*** The current Section 15.209 limits, which define out-of-band emission limits for unlicensed devices, were adopted when unlicensed devices operated with narrow band emissions and operation in the TV band was prohibited. Testing conducted by CRC, and previously submitted by MSTV, has documented the fact that the existing Section 15.209 limits are inadequate to protect wideband DTV signals and TV viewers.[19] Permitting emissions from TV band devices at these levels will interfere with digital television sets to such a degree that the television will go blank on all channels where such energy is present; such interference can occur at a distance of up to 78 feet from the "low power" device. Thus, as discussed more fully below in Section III, IEEE 802.22 and others have shown that the Section 15.209 limits must be reduced by 33 dB to avoid interference.
- ***The Commission must conduct testing to ensure that the final rules sufficiently protect television viewers.*** Just as theoretical interference models did not predict the interference between CMRS and public safety communications systems in the 800 MHz band,[20] they cannot reliably predict whether unlicensed devices would harm broadcast television reception. As MSTV and NAB have previously urged, the Commission should not allow new uses of the television broadcast spectrum without actual proof – in the form of detailed engineering studies and field tests – that such uses will preserve access to free, over-the-air television. To that end, any proposed "test devices" submitted to the Commission by third parties in support of proposals in this proceeding should be made available for inspection by

[19] *See* Joint Comments of MSTV and NAB, ET Docket No. 04-186 (filed Nov. 30, 2004) ("MSTV/NAB White Spaces Comments") at App. A.

[20] *See Improving Public Safety Communications in the 800 MHz Band*, 19 FCC Rcd 14969, at ¶ 13 (2004) ("Despite the claims by some that licensees in the cellular telephone bands cause little interference to 800 MHz band public safety systems, strong evidence exists to the contrary").

the public.[21] In addition, the Commission should publish its testing methodology far in advance of the actual testing to allow for public input and comment.

- ***Any new devices allowed to operate in the broadcast spectrum should be exclusively licensed; no unlicensed operation should be allowed.*** As compared to an "unlicensed" device regime, a licensed system provides more reliable protection to users of existing services, leads to more efficient use of the broadcast spectrum, and reaps significant economic benefits for the American taxpayer. Providing for licensed use of any "white spaces" in the broadcast spectrum is particularly appropriate given the vast amounts of unlicensed spectrum in other bands that the Commission has made available in recent years.
- ***The Commission must enact a rigorous enforcement program.*** If the Commission allows TV band devices to operate in the spectrum, it must develop a reliable system to enforce the prohibition on these devices interfering with licensed services. Without such enforcement mechanisms, the rules prohibiting interference with incumbent services will be ineffective.

III. THE INTERFERENCE HARMS POSED BY TV BAND DEVICES ARE NOT ADEQUATELY ADDRESSED IN THE FNPRM.

In designing rules to safeguard the viewing public's access to digital television, it is important to recognize that interference from TV band devices will be caused not at the point of transmission (*i.e.*, the television tower), but rather at the point of reception (*i.e.*, the television set in a family's living room, kitchen, bedroom, basement, or elsewhere). Television sets are scattered through a television station's service area, and whenever any device is in proximity to any television receiver the risk of interference will increase. As discussed below, the FNPRM would leave millions of viewers unprotected from such interference.

Specifically, there are four types of interference TV band devices cause to DTV receivers: (1) co-channel interference; (2) adjacent channel interference; [22] (3) interference from

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[21] *See Office of Engineering and Technology Invites Submittal of Prototype TV Band Devices For Testing*, DA 06-2571 (rel. Dec. 21, 2006).

[22] MSTV and NAB generally support the co-channel and adjacent channel D/U protection ratios proposed in the initial NPRM but these protections must apply to all TV band operations, including personal/portable devices. Recent testing by the CRC supports the proposed D/U ratios for DTV of -26 dB for upper adjacent channel operations, and -28 dB for lower adjacent channel

taboo channels and unwanted intermodulation products; and (4) out-of-band interference. New testing by the CRC suggests that interference can also occur to DTV receivers on second and third adjacent channels and on channels N+7, N+14 and N+15. The CRC testing also provides evidence that the performance of a DTV receiver can be adversely affected by the presence of multiple interfering signals causing unwanted intermodulation products and interference. A more detailed description of these types of interference is presented in the paper at Exhibit A, prepared by Robert Eckert.

The Commission is required to protect incumbent services from all types of interference,[23] but upholding this requirement is particularly challenging in the context of the unprecedented spectrum-sharing proposal at issue in this proceeding. To date, the type of "low power" devices (*i.e.*, unlicensed devices) proposed have been allowed to operate only in bands with little or no licensed, communications services. By introducing such devices into spectrum already used to deliver the public's free, over-the-air television service, the risks from all types of interference become quite significant, but the FNPRM falls far short of addressing those risks.

A. Any Operation By A TV Band Device On A Co-Channel Basis Will Cause Interference For Miles.

Unless rules adopted in this proceeding reliably prevent TV band devices from operating on the same channel (*i.e.*, co-channel) as local television stations, consumers' sets will experience severe and incurable interference. Such interference will disable a consumer's ability

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operations. These values will ensure that DTV operations are provided adequate protection on co- and adjacent channels taking into account the fact that TV band devices may operate with different modulation schemes and multiple TV band devices may be present. These values will also ensure that TV band devices provide at least the same level of protection as TV licensees receive from other licensed operations. However, based on testing by CRC, D/U ratios for other channels should also be developed to ensure protection of TV viewers as discussed in Section III E, herein.

[23] *See* 47 U.S.C. §301; 47 C.F.R. § 15.5.

to receive the co-channel television station for up to tens of miles depending on the power and antenna height of the TV band device.

The severe effects of such co-channel interference are verified by an analysis of data submitted previously by Intel, despite its support of an aggressive "unlicensed devices" regime. Specifically, in its comments to the Commission, Intel suggested that the interference range of a 100 mW personal/portable unlicensed device is approximately 8 kilometers (or 5 miles) from a television contour, therefore acknowledging that in order not to cause interference to TV reception, any TV band device must operate at a sufficiently large distance away from the television contour.[24] In fact, the actual zone of interference would be much larger, as Intel's analysis incorrectly assumes a 14 dB antenna discrimination factor.[25] In any event, even the parties with least incentive to protect television viewership, such as Intel, acknowledge that TV band device operation on a co-channel can cause significant interference to television viewers over a large area.

B. The Current Sensing Proposals Are Inadequate To Protect Against Co-Channel Interference.

Despite the acknowledged effects of co-channel interference on television receivers, the FNPRM would allow such interference to occur. The FNPRM's proposal to control for such

[24] *See* Comments of Intel Corp, ET Docket No. 04-186 (filed Nov. 30, 2004) ("Intel Comments") at App. A. This calculation is based on an 8 km or 5 mile radius. In some cases, since television receivers can be located in front of a TV band device, the 14 dB antenna discrimination would not apply and the actual calculated interference area would be much larger. Moreover. This is based on a 100 mW device. In this proceeding, however, the FCC has contemplated power levels of up to 4 watts.

[25] Intel assumes that the TV band device will always be located a sufficient distance from the TV station contour such that any emissions from the TV band device will be into the "back" of the TV antenna and the front-to-back discrimination of the TV antenna can be taken into account. Intel also assumes the TV antenna and TV band device are at different heights such that there is a "slant angle" to the TV receiving antenna. The -118 dBm sensing level proposed by Intel would actually allow the TV band device to be located inside the TV station contour in some instances where the use of these antenna discrimination factors would not apply.

interference by having devices "sense" the presence of a co-channel television signal (and then cease operating if a television signal of a certain level is sensed) falls far short of protections necessary to protect the viewing public.

1. The Proposal Of A -116 dBm Sensing Level Is Insufficient To Protect Incumbent Services.

The -116 dBm sensing level proposed in the FNPRM will fail to adequately protect licensed television services.[26] At a minimum, a sensing detection level must ensure that a TV band device is a sufficient distance *outside* the protected contour of the TV station to prevent interference, but the level proposed would often allow operation *within* the protected contour. Indeed, the proposed sensing level for a device that can operate with up to 4 Watts is higher (*i.e.*, less strict) than the level proposed by Intel for even a 100 milliwatt device, which itself was insufficient.[27] As discussed below, a sensing threshold set at the level proposed would do little to protect the viewing public from harmful co-channel interference.

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[26] *See Unlicensed Operation in the TV Broadcast Bands*, First Report and Order and Further Notice of Proposed Rulemaking, ET Docket No. 04-186, FCC 06-156 (rel. Oct. 18, 2006) ("First R&O and FNPRM") at App. B, §15.707(f). The Commission also did not define over what bandwidth this threshold detection value is to be measured other than to suggest that detection is "within the TV band device channel bandwidth." The specification of a measurement bandwidth is important since it can have a significant impact on the detection level. For example, there is a 27 dB difference between signals of -116 dBm if they are measured using a 6 MHz bandwidth or a 10 kHz bandwidth. Therefore, it is essential to also specify the bandwidth for the detection threshold level. Since TV operations use a 6 MHz channel, we recommend that any detection threshold level used for protection of TV operations be specified over 6 MHz bandwidths so as to match the TV channels identified in Section 73.602 of the Commission's rules. If smaller bandwidths are permitted, the threshold level must be lowered to take into account the reduced energy of the TV signal being measured in the smaller bandwidth.

[27] *See* Intel Comments. Intel's interference analysis is predicated on the assumption that a –85 dBm signal level will always be at least 8 kilometers beyond the Grade B contour and therefore one can reduce the interfering signal of the unlicensed device by a factor of 20 dB or 100 times. In fact, DTV signals at levels at or below –85 dBm can and do occur within the DTV service area where this reduction is not appropriate and the unlicensed device would cause additional significant interference to DTV viewers. The detection level suggested by Intel also fails to take account of signal variability, which necessitates a lower (*i.e.*, stricter) detection threshold.

Both the previous Intel and the current FNRPM sensing proposals fail to recognize that TV signal levels are not uniformly distributed throughout a station's service area; consequently, there are locations where television receivers may not receive a television signal that is adequate for viewing.[28] The current sensing proposals, however, would allow a device to transmit on a co-channel basis, inside the TV contour, despite the fact that interference could be caused to TV viewers for miles. That is, the sensing proposals operate under the false presumption that if the television signal is weak (*i.e.*, below the proposed detection threshold), then the TV band device is far enough outside a television station's service area to not cause harmful interference. The proposed detection threshold level of -116 dBm clearly does not provide this level of protection.[29]

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[28] The TV viewer will avoid locations where the TV signal is not adequate (for example, using an indoor antenna in a basement location) because the TV receiver will not operate properly. The user of the TV band device, however, has no such incentive to avoid poor TV reception locations inside the TV contour. In fact, the TV band device would actually provide the user with more channels and capacity and the user would be unaware of the fact that the device was causing interference to TV reception.

[29] The detection threshold of -116 dBm is referenced to a 0 dBi gain antenna. For the purposes of this example, assume that the -116 dBm detection threshold is measured over the 6 MHz TV channel. There are therefore actual physical differences in the "receive" system used by the unlicensed device and a TV receiver. The -116 dBm received by a TV band device is equivalent to a -99 dBm signal received by a TV receiver taking into account the difference in antenna gain and height between the TV and the device operation. (There is a 10 dB difference in antenna gain between a typical outdoor TV antenna and the 0 dBi sensing antenna required under the proposed rules (0 dBi vs. 10 dBi). There is also a 7 dB difference in the height of the antennas (6 feet vs. 30 feet)). The question then becomes can a TV signal of -99 dBm or less occur within or close to the protected TV contour? The answer is clearly yes. In fact, in limited measurements taken in 1998 by MSTV of WETA's coverage, three outdoor sites *within the protected contour* (located 36.4, 37.8, and 42.9 miles from the transmitter) were found to have signal levels less than -99 dBm or less than -116 dBm referenced to a 0 dBi antenna. Therefore, a TV band device sensing at -116 dBm at these three locations would have failed to protect TV viewers. In addition, at many sites, the signal level was only a few decibels above the -99 dBm level. Since the measurement procedure called for locating the "maximum" signal level at each location, it is highly likely that the "average" signal level at these locations would be well below the -99 dBm level. It should also be noted that all of these measurements were taken "outdoors" at sites where reception was expected to be successful. In fact, when the TV band devices were assumed to be located indoors, where the TV signal was attenuated by only 10 dB, the analysis showed 38

In addition, the sensing level must be low enough to protect against the "hidden node" problem, whereby the TV band device is located behind an obstruction, such as a building or a hill, which prevents it from receiving the television signal. If this occurs, the channel would appear "vacant" to the TV band device's receiver and the device would therefore transmit, even though the device is well inside the service area of a co-channel television station.

The sensing proposals erroneously assume that a predetermined detection threshold level (whether -116 dBm or otherwise) will guarantee that the unlicensed device will be sufficiently outside the protected television station's service area, and thus the TV band device will not cause interference. In fact, as discussed above, signal detection and sensing alone cannot accurately predict location.[30] As there may be locations within the service area where the signal level may be below the designated sensing detection level, the current proposed -116 dBm sensing level will be ineffective at preventing interference. As outlined in Section V, below, additional protections are necessary to prevent co-channel interference.

2. The Comparison Of The Use Of Spectrum Sensing In The 5 GHz Band With The Current Situation Is Misplaced.

The FNPRM, and other commenting parties, have misused the fact that spectrum sensing has preliminarily been used to prevent interference in the 5 GHz band, as support for the

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locations *well within WETA's protected contour*. In these locations, the signal level received by a TV band device would have been less than -116 dBm and sensing would have failed, resulting in significant interference to surrounding TV viewers. Additional measurements are currently being conducted in the Washington/Baltimore area, and will be submitted in the reply phase of this proceeding. Preliminary results support previous findings.

[30] Proponents of a sensing approach posit that by using very sensitive receivers, sensing will effectively prevent interference. While it is potentially possible to determine a sensing level that will ensure that low power devices are operating outside of the contour, this is highly impractical. If the detection level is set low enough to actually provide protection to DTV viewers, the detection level will be well below the ambient "noise floor." The result will be that all spectrum will appear occupied and the detector will never find unused or unoccupied spectrum.

proposition that spectrum sensing alone will be effective in preventing interference in the television band.[31] This comparison confuses the problem of transmitter detection (for which sensing is relatively effective) with the real issue of protecting television reception from interference (for which sensing is woefully inadequate). While the FNPRM acknowledges in passing the differences between the effectiveness of sensing in the 5 GHz band and in the broadcast spectrum,[32] it mistakenly argues that the problem can be fixed with a more sensitive detection threshold.[33] In fact, it is far easier to use sensing technologies to protect a 5 GHz radar receiver than consumers' DTV reception.

First, significant differences in the location of the receivers indicate that sensing will be markedly less effective in the television context in terms of preventing interference. In the 5 GHz band, the radar receiver to be protected is co-located with the radar transmitter whose emissions can be "sensed," making protection of the radar receiver relatively easy and straightforward technically. In contrast, television receivers are not co-located with the television transmitter, but rather are located throughout a television station's service area. Consequently, there is no signal that can be sensed to tell an unlicensed device how close it is to a television receiver or viewer.

Second, unlike broadcast signals, which are weak, radar signals are strong; as a result, radar signals are easier to detect. Furthermore, the antennas for unlicensed devices at 5 GHz are small, efficient and have a uniform performance across the 5 GHz band. In the broadcast arena, on the other hand, building a small, efficient and practical antenna to detect "occupied channels"

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[31] *See* First R&O and FNPRM at ¶¶ 36-37; Michael J. Marcus, Paul Kolodzy, & Andrew Lippman, *Why Unlicensed Use of Vacant TV Spectrum Will Not Cause Interference to DTV Viewers*, New America Foundation Issue Brief (July 2006).

[32] *See* First R&O and FNPRM at ¶¶ 36-37.

[33] *See Id.* at ¶ 37.

that operates with a uniform performance across all television channels is extremely difficult and complex. This is because an antenna's ability to receive a transmitted signal is related to the wavelength of the signal received, which thus impacts the necessary size of the physical antenna. At 5 GHz, the wavelength of the signal is less than about 2.5 inches, and therefore, a very effective sensing antenna can be made in a small physical space. In the television spectrum, however, there are three separate frequency bands that extend across both the VHF and UHF region of the spectrum. The wavelength size can vary from 17 inches in the upper UHF band to 18 feet at VHF bands.[34] Consequently, even a poorly functioning antenna for an unlicensed device in the television band would need to be significantly larger than an antenna at 5 GHz.

Finally, in contrast to television receivers, radar systems are robust and can effectively deal with interference. Thus, errors in detection and inadvertent unlicensed operation do not result in significant degradation of the radar system, whereas any "low power" operation in the television band caused by errors in detection will result in widespread interference to viewers. Therefore, detection by TV band devices must be correct *all* of the time to avoid harmful interference.

In sum, there is currently no practical sensing level that will guarantee accuracy in all situations. The Commission must therefore avoid utilizing sensing as the *only* means of preventing co-channel interference in the broadcast spectrum and should ensure that protection is provided through the use of appropriate D/U ratios and the implementation of non-sensing means, such as geo-location and professional installation, designed to maintain required separation distances to the TV contour.

[34] The wavelength of UHF Channel 51 is about 17 inches and the wavelength of VHF channel 2 is about 18 feet. The formula is wavelength (meters) = 300/f in MHz.

C. Any Operation of a TV Band Device On A Television Station's First Adjacent Channel Will Harm Reception.

In addition to the harms of co-channel operation, any operation of TV band devices on a television station's first adjacent channel will also cause severe and unacceptable interference to licensed television services. The FNPRM, however, fails to prevent such operation and thus leaves consumers' vulnerable.

The following analysis demonstrates the harms of adjacent channel operations. Three signal levels (from moderately strong to weak signal conditions) are considered for DTV reception and a free space propagation model as suggested by the Commission is assumed for the interfering TV band device.[35] Using the same adjacent channel protections proposed by the Commission in its initial NPRM,[36] the following table shows the impact of personal/portable devices operating at 100 mW and at 400 mW: [37]

TV Band Device Power	**DTV Signal Strength**	**Interference to DTV Reception**
100 mW	41 dBu	780 meters
	59 dBu	100 meters
	69 dBu	30 meters
400 mW	41 dBu	1.5 kilometers
	59 dBu	200 meters
	69 dBu	60 meters

As indicated by the above chart, DTV viewers, even hundreds of meters from a 100 mW TV band device operating on a first adjacent channel, will experience harmful interference. The

[35] This is consistent with the Commission's recommendation to use free space propagation calculations for distances up to 1.5 kilometers. *See* Initial White Spaces NPRM at ¶ 31, note 50.

[36] *See Id.* at ¶¶ 29-31.

[37] 400 mW is the proposed maximum output power including antenna gain for personal/portable unlicensed devices.

interference concerns are even greater for the higher powered 400 mW devices which may cause interference to DTV services for over a kilometer.[38]

Since received signal strength will vary throughout the TV station's service area and will depend on the type of antenna a viewer is using for reception, there is no practical way to predict or avoid this type of interference. As significant interference will occur, even with lower power personal/portable devices, it is clear that the Commission must exclude *all* TV band devices from operating within the contour of a first adjacent channel. IEEE 802.22 has reached the same conclusion in its studies: devices should not be allowed to operate within a first adjacent channel.[39]

Further, while protection of the first adjacent channel is most important, it is noteworthy that TV band devices may also cause interference to the second and third adjacent channels as well as to channels N+7, N+14 and N+15. The FNPRM makes no effort to address these interference concerns, which must be addressed before any TV band device can be allowed in the broadcast spectrum.

D. CRC TV Receiver Tests Demonstrate Interference From TV Band Devices On Adjacent Channels, Taboo Channels, As Well As Additional Interference Caused By Multiple Devices.

To assist the Commission's effort in testing television receivers, MSTV funded laboratory testing by CRC of five VSB receivers to determine, and quantify, their interference

[38] *See* Exhibit A for calculation of the keep-out distance for a 4 W TV band device.

[39] *See Ex Parte* Presentation of IEEE 802.22, ET Docket No. 04-186 (filed Oct. 3, 2005) ("IEEE-802.22 Presentation"). IEEE 802.22 is responsible for developing standards for operating Wireless LANs within the TV bands. In October 2005, it submitted an *ex parte* filing with the FCC to report on its activities and findings to date. The report concluded, among other findings, that unlicensed systems should not operate within a co- and first adjacent channel contour of a DTV station. IEEE 802.22 has also provided the Commission with numbers indicating the appropriate distances for these devices to be operating outside of the contour.

performance.[40] The five receivers included a current DTV model, purchased specifically for these tests, as well as other current and recent DTV models. The study is included in Exhibit B. Listed below is a summary of the findings:

1. Interference Performance Can Vary Significantly Across DTV Receivers And Interference Mechanisms.

The results of the CRC tests indicate that interference performance can vary substantially across different DTV receivers and for different interference mechanisms. That is, there was no single DTV receiver that provided the best or worst performance across all tests and measurements. For example, receiver #5 (as described more fully in Exhibit B) was one of the better performing receivers in the weak signal single interferer case. In the higher signal single interferer cases, however, it was one of the worst performing receivers and was an average performer in the case of multiple interfering signals.

This finding suggests that in developing the appropriate D/U protection ratios, the Commission should consider selecting a value for each mechanism that is met by all measured TV receivers and therefore protects all TV viewers. The median measured receiver values for each mechanism should not be used. Such an approach lacks any technical justification, especially with regard to developing protections for a Part 15 unlicensed TV band device. First, there is no actual measured DTV receiver with this performance; thus, the use of median values would actually protect less than half of the TV measured receivers from all interference mechanisms.

Second, the interference "cliff effect" mechanism for DTV makes the use of median values unacceptable and technically unsuitable. While median values have been used in certain

[40] CRC tested all of the receivers on all adjacent and taboo channels from first adjacent (N ±1) to N ±15. No co-channel interference tests were conducted.

instances for analog television receivers, such receivers degrade gradually and a receiver that is one or two dB under the median performance will merely display a slightly degraded picture. Due to the "cliff effect" for DTV, a DTV receiver that is one or two dB under the median performance ceases to display any picture and sound. The premise and rationale of this rulemaking has been to prevent harmful interference to TV viewers and other licensed operations. This cannot be technically accomplished with the use of median performance values.

Third, the sample size, and the measurements taken to date, are too small and uncorrelated to actual receiver population. The Commission must select values met by all measured receivers, and provide some margin above those values to account for differences in modulation schemes used by TV band devices, in order to protect TV viewers from potentially multiple interfering signals from these devices.

2. Interference On First Adjacent Channels Is A Serious Concern And Therefore First Adjacent Use Should Be Avoided Within A TV Station's Protected Contour.

Based on the CRC measurements, the lowest D/U ratios or greatest protection of DTV receivers is required on the first adjacent channels. For some receivers, the upper adjacent is the most critical, while for other receivers the lower adjacent is most important. CRC calculated the radius of interference for each receiver assuming that the interfering device is operating at 100 mW with a 6 dBi transmitting antenna gain.[41] These interference distances are shown in the CRC Report attached as Exhibit B. All of the adjacent channel interference distances were substantially greater than 10 meters. In some cases, for example, in the case where the desired

[41] In the initial NPRM, the Commission proposed this level for personal/portable unlicensed devices. *See* Initial White Spaces NPRM at App B. In its subsequent FNPRM, the Commission has proposed that TV band devices can operate up to 4 watts. *See* First R&O and FNPRM at App. B.

signal was only 7 dB above the value at the edge of contour, the interference distances for the 5 DTV receivers varied from 60.9 meters to 229 meters. Moreover, the presence of a second interfering signal further lowered the required protection levels by as much as 4.5 dB; thereby further increasing these distances.

3. Interference On Second And Third Adjacent Channels Is Very Problematic As Well As Operations On N+7 And On "Image" Frequencies N+14 And N+15.

The CRC measurement results suggest that operation of TV band devices on second and third adjacent channels could also be problematic. The single interfering signal tests show that TV device operation on second and third adjacent channels would cause interference at distances well beyond the 10 meters. For example, a TV band device operating at only 400 mw, would cause interference to receiver 5 at a distance of 43.5 meters on the lower second adjacent channel and 17.7 meters on the lower third adjacent channel. For single interfering signals, operation on the second adjacent channel was also found to be worse than the third adjacent channel.

The CRC measurement results also suggest that operation of TV bands devices on the fourteen and fifteen channels above could be problematic. The data demonstrates that, depending on the design of the TV receiver and the filtering of the undesired signal, an interference radius of 100 meters or more is possible.

In the case of multiple interfering signals, operation on the upper and lower third adjacent channel was found to be even worse. For example, in the case of interfering signals on both the upper and lower third adjacent channel, the interference performance of receivers 3 and 4 are reduced by 17.0 dB and 16.0 dB respectively and the resultant D/U ratios are reduced to -26.6 dB and -28 dB. These values indicate that TV band device operation on these channels within the

protected contour would not protect TV viewers with DTV receivers that exhibit similar performance characteristics.

4. Multiple Interfering Signals Will Reduce Interference Performance And D/U Protection Ratios Of DTV Receivers.

The CRC tests also considered the effects to TV receivers when two interfering signals occurred on two different channels. As shown, the introduction of a second interfering signal on another channel, even at a level that is half the power (-3 dB) of the first interferer, resulted in significant reduction in the interference rejection capability and performance of the DTV receiver and in the D/U ratios derived from the single interfering signal case. For example, the D/U ratio for receiver 5 on the first upper adjacent channel was reduced by 4.5 dB with the introduction of a second interfering signal at half the power on the first lower adjacent channel. Other combinations resulted in even larger degradations of receiver performance. In fact, the performance of receiver 5 with regard to a single interfering N+6 channel or D/U ratio was reduced by 33 dB with the introduction of a second interferer on channel N+3. These larger degradations are presumably a result of non-linear effects of the intermodulation products.

These test results suggest that additional margins should be included in the D/U ratios to take into account multiple interfering signals. The CRC results show that the worst case appears to be N+x and N+2x. As a number of TV band devices will be operating on multiple channels in close proximity to a TV receiver, MSTV urges the Commission to conduct exhaustive testing and evaluation of multiple signal tests.

E. TV Band Devices Have The Potential To Cause Severe Out-of-Band Interference.

Out-of-band emissions (*i.e.*, interference from energy generated by a device on channels or frequencies outside the channel being used by the television station) at the levels proposed to

be allowed by the FNPRM will pose a particularly serious threat to television receivers. Specifically, the FNPRM proposes to use the existing Part 15.209 emission limits, noting that these limits have been in use for years.[42] It was never anticipated, however, that Part 15 limits would apply to devices actually operating in the TV bands, and they are ineffective at preventing interference in this case.

In proposing use of the current Part 15.209 limits, the FNPRM fails to recognize the technical reasons why these limits have not been problematic previously. First and foremost, the highest out-of-band emissions generally occur closest to the operating frequency of an unlicensed device. The television band is currently a "restricted band" and unlicensed devices are, and have been, prohibited from operating on any television channel. Therefore, the out-of-band emissions in the band have been far from the device's operating frequency, and generally well below the Part 15.209 limits. Secondly, until recently, most unlicensed devices operated with narrow bandwidths. Consequently, the out-of-band emissions from these devices were generally narrowband "spikes" that presented low interference risks.

The technical situation is quite different, however, in the context of the television band and the types of "low power" devices likely to be deployed. The devices the Commission is now proposing to allow in the television band are wide band devices which, of course, will have wide out-of-band emissions. Furthermore, because the devices will be operating within the television band itself, the out-of-band emissions will also be much closer to the television operating frequency and may be operating right at the Part 15.209 levels. These factors drastically diminish the effectiveness of the Part 15.209 limits.

[42] *See* First R&O and FNPRM at ¶ 60.

Concerns with the application of Part 15.209 limits to the television band are not only theoretical; CRC and MSTV have conducted laboratory testing and field studies showing that operation of TV band devices at the FNPRM's proposed out-of-band limits are inadequate and will cause significant interference.[43] These tests have demonstrated that unlicensed devices, complying with the FCC's proposed out-of-band emission limits, could cause interference to DTV sets at distances up to 78 feet and interference to analog TV sets up to 452 feet.[44]

In addition to MSTV and NAB, others, including Motorola[45] and IEEE 802.22, [46] have confirmed that desensitization interference to TV receivers by new devices is a real problem that needs to be addressed. In fact, IEEE 802.22 independently studied the out-of-band emission problem highlighted by MSTV, and the working group tentatively determined that the FCC out-of-band limits are insufficient to protect DTV receivers by some 33 dB.[47] These studies, when viewed alongside the fact that the Part 15.209 limits have never been used to protect operations within the broadcast spectrum, support the conclusion that a far more stringent out-of-band emission limit is necessary in order to protect the viewing public.

Furthermore, these harmful out-of-band emissions will degrade use of consumer products such as VCRs, and, importantly, analog to-digital converter boxes. As MSTV, NAB and the Consumer Electronics Association recently explained to the NTIA and Commission,

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[43] These CRC laboratory tests are included in Exhibits C and D.

[44] *See* MSTV/NAB White Spaces Comments at App. A.

[45] *See* Comments of Motorola, ET Docket No. 04-186 (filed Nov. 30, 2004) ("Motorola Comments") at 12 ("Part 15.209(a) emission levels do not provide adequate protection to TV receivers within the protected contour").

[46] *See* IEEE 802.22 Presentation at Slide 8 (the FCC's proposed out-of-band emission requirements are insufficient to protect DTV receivers by some 33 dB for 1 dB desensitization of DTV receivers).

[47] *See Id.*

such converter boxes are essential to "protect the rights of all Americans to receive free, over-the-air television service after the transition."[48] But even assuming a successful deployment of converter boxes, which will be aided in large part by the federal government's $1.5 billion converter box program, many analog households could end up without television services due to out-of-band emissions from TV band devices. To protect such viewers, the Commission must determine new, stricter out-of-band emission limits before allowing any TV band device to operate in the broadcast spectrum. MSTV and NAB urge the Commission to specify the out-of-band emission limits for these TV band devices in terms of a specific transmitter mask, rather than solely relying on new lower 15.209 limits. The new mask should take into account the testing, analysis and findings of MSTV, CRC and IEEE 802.22.

F. TV Band Devices Should Be Extensively Tested Prior to Developing Rules and Measurement Procedures for Operation in the TV Bands.

MSTV and NAB support the Commission's intent to conduct extensive testing as part of the process to develop technical rules and compliance measurement procedures for TV band devices.[49] Both testing to develop appropriate standards and compliance measurement procedures to ensure that devices comply with those standards *are critical* components of this rule making to ensure that TV band devices do not cause interference to TV viewers and other licensed operations. Accordingly, MSTV and NAB urge the Commission to publish and seek public comment on its testing program and the measurement procedures for these TV band devices.

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[48] Joint Comments of MSTV and NAB, Docket No. 060512129-6129-01 (filed Sep. 25, 2006) at 2.

[49] *See* First R&O and FNPRM at ¶ 58.

If sensing is permitted and employed in a TV band device, MSTV and NAB agree with the Commission that all three signal types, an ATSC DTV signal, an NTSC signal and a 200 kHz FM signal, should be used to test the sensing capability of a TV band device. However, MSTV and NAB do not agree with the Commission's suggested procedure of merely adjusting the "peak levels" of these signals to the sensing detection threshold. Adjusting the "peak levels" to the threshold value is an inadequate test procedure to evaluate "real world" over-the-air TV signals, that can be subject to severe multipath and other propagation effects. The ATSC A/74 DTV Receiver recommended practices require DTV receivers to be tested using 50 field ensembles or "real world" signal captures that take into account actual multipath and propagation effects.[50] These 50 captures, or at a minimum some significant subset of these captures, should be used to test the TV band device just as they are used by electronic circuit designers to test the performance of DTV receivers. That is, the TV band device should be tested with each of these captures and the signal level of each capture should be adjusted such that the "peak level" as measured over 6 MHz is raised to the threshold level where the TV band device should cease operating on the channel. This will ensure that the "sensing" technique actually works with real world TV signals, and narrowband detection techniques, such as pilot detection, do not inadvertently let the unlicensed device operate in situations where the pilot carrier is faded but the energy across the entire DTV signal is above the threshold and the signal would provide a usable DTV signal level within the interference range of the unlicensed device. MSTV and NAB also do not believe that there should be any "pass/fail" ratio. The TV band device should operate correctly with *all* ensembles and cease operation when the ensemble is at the specified threshold.

[50] *See ATSC Recommended Practice: Receiver Performance Guidelines*, Document A/74, June 18, 2004. These 50 ensembles are actual over-the-air signal captures recorded in the Washington, DC area and in New York City.

This is consistent with Part 15 requirements that unlicensed devices must not cause interference to licensed operations.[51]

IEEE 802.22 is also currently in the process of defining a uniform methodology to evaluate the sensing level performance of these TV band devices along the lines suggested above.[52] MSTV and NAB support this effort and believe such an activity will help the Commission in its effort to develop testing methodology and compliance measurement procedures. Specifically, IEEE 802.22 proposes using off-air signal captures to evaluate the various sensing proposals.[53] The IEEE 802.22 also defines the threshold levels over a 6 MHz bandwidth for TV signals, and over a 200 kHz bandwidth for Part 74 devices.

IV. IF DEVICES ARE ALLOWED TO OPERATE ON AN UNLICENSED BASIS, THE COMMISSION MUST OVERCOME ITS LACK OF AN EFFECTIVE MEANS TO ENFORCE ITS PROHIBITION ON INTERFERENCE FROM TV BAND DEVICES TO EXISTING LICENSED SERVICES.

Particularly if the Commission allows TV band devices to operate on an unlicensed basis, as some parties have proposed,[54] enforcement of interference protection rules will be difficult at best. One of the most significant problems with an unlicensed devices regime is the fact that a consumer has no idea what is causing the interference. Even if a consumer can identify that their interruption in television service is due to interference from an unlicensed device and report it,

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[51] *See* 47 C.F.R. § 15.5(d).

[52] Note that while IEEE 802.22 has proposed a DTV detection threshold level of -116 dBm over a 6 MHz bandwidth, it specifically states that sensing alone is not sufficient and requires both GPS and professional installation to ensure that the device is located outside the service area.

[53] IEEE 802.22 proposes that when testing the various sensing proposals, it is imperative the testing be conducted with the complete system not just the sensor. The TV band device should include a front end and a functioning tuner to properly assess the effect of these components on the sensor.

[54] *See* Comments of Microsoft, ET Docket No. 04-186 (filed Nov. 30, 2004); Comments of the New America Foundation, *et al.*, ET Docket No. 04-186 (filed Nov. 30, 2004) ("NAF Comments").

little can be done to help that viewer. Multiple parties have submitted comments throughout this proceeding addressing this concern and the difficulties the Commission will face in finding the interfering device and shutting it off.[55] If these devices are allowed to operate on an unlicensed basis, access to free spectrum will mean that an untold number of devices will be operating in the band and there will be no records as to where and when they are operating. The problematic effects of an unlicensed system will be most evident in highly populated areas where there will be countless unlicensed devices in operation. And even if interference is reported and linked to unlicensed devices, the Commission will lack the means, and potentially the authority, to find and shut down the interfering devices.

A. In An Unlicensed Regime, Consumers Will Be Unable To Resolve Problems With Interference.

If the Commission authorizes TV band devices to operate on an unlicensed basis within the broadcast spectrum, consumers will experience harmful interference and will be ill equipped to both identify such interference and eradicate its effects. While in theory a consumer could eliminate this problem by turning off the unlicensed device, the Commission should not presume that viewers will understand the connection between unlicensed TV band devices and the problems with their television set(s). Consumers will not know they are causing interference to their neighbors. These devices will be on throughout the day and consequently, there will be few

[55] *See* Comments of the Society of Broadcast Engineers, ET Docket No. 04-186 (filed Nov. 30, 2004) at 7 ("the difficulty of *finding* an offending high power Part 15 device, to say nothing of persuading the operator of that device to shut it down"); Comments of the National Cable & Telecommunications Association, ET Docket No. 04-186 (filed Nov. 30, 2004) at 3 ("the presence of hundreds or thousands of the devices could create an electromagnetic cloud making it nearly impossible to identify a single source of interference in the presence of many such sources"); Comments of Qualcomm, Inc., ET Docket No. 04-186 (filed Nov. 30, 2004) at 12 (it could be "impossible" to "pinpoint and cure harmful interference" from unlicensed devices).

opportunities for affected consumers to discover the relationship between the unlicensed device and lack of television service.

Furthermore, the initial NPRM mistakenly assumes that television sets within 10 meters of a TV band device will be under the control of the same user, [56] and therefore infers that interference concerns would be less severe. However, both the underlying premise and the resulting conclusion are in fact false. As noted above, interference will occur well beyond 10 meters. Also, mere control over both devices does not guarantee that a user will be able to identify and fix the interference. In addition, in crowded areas, such as hotels, offices, and apartment buildings, a television set may often be within 10 meters of an interfering unlicensed device that is not under the control of the person whose television has inexplicably ceased operation. This will make both identification and resolution of the problem even more improbable. As neither the operator of the TV band device, nor the person experiencing interference with DTV service will be aware of the connection between the two, the likely result will be that consumers will return their DTV sets. Consumers will be frustrated by the inexplicable blank screens and will have no way of remedying the situation.

B. The Commission Lacks The Means, And Potentially The Authority, To Resolve The Problems With Unlicensed Devices.

While some have argued that the Commission will be able to effectively regulate these problems by shutting down devices or recalling all unlicensed devices found to cause interference, there has been little said as to *how* the problem could be identified and *how* enforcement measures, such as a recall, could be accomplished.[57] The Commission has the

[56] *See* Initial White Spaces NPRM at ¶ 31, note 50.

[57] *See* NAF Comments at 34 (asserting that the Commission can make clear it will "cancel its certification of devices and may order recalls of devices if necessary").

authority to stop the manufacture and sale of new devices within the United States. The problem, however, is that once these devices are in the market, there is no practical way of identifying even which category of devices may be causing interference, let alone pinpointing a specific device.[58]

Furthermore, even if interfering TV band devices are actually identified, the Commission potentially lacks the authority, or at a minimum, has historically demonstrated an unwillingness, to recall such interfering devices. Recently, for example, it was discovered that FM transmitters designed for use with XM Satellite Radio Inc. ("XM") and Sirius Satellite Radio Inc. ("Sirius") radios did not comply with Commission regulations. A study conducted by NAB found that of the 17 devices tested, 13 exceeded the field strength ceilings for operation of unlicensed devices under the Commission's Part 15 rules.[59] Both XM and Sirius eventually admitted that these devices were noncompliant, and the Commission ordered the manufacturers to cease producing such devices.[60]

While the Commission has worked with the two companies to ensure that any new devices comply with the standards, a recall was never ordered. In fact, the Commission's level of involvement in this issue was only possible because XM and Sirius are FCC licensees. If TV band devices are allowed to operate within the broadcast spectrum on an unlicensed basis, the Commission will have even less oversight authority. Given the lack of a recall order after

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[58] Importantly, unlicensed spectrum use is not necessarily connected to a "service," which makes interference mitigation and elimination especially difficult. In the unlicensed world, the device itself is the interfering entity and there may be no service provider responsible for eliminating the interference being caused.

[59] *See Report on Part 15 FM Modulator Device*, June 2, 2006, *available at* http://www.nab.org/xert/corpcomm/NAB_Part15 Study.pdf (last visited Jan. 31, 2007).

[60] Carolyn Y. Johnson, *Getting Howard Stern off NPR: Regulators, Device Makers Try to Fix Other Signals 'Bleeding' Into FM*, Boston Globe, Dec. 21, 2006.

serious violations by XM and Sirius that caused widespread radio interference, it is difficult to believe the Commission would be in a position to order a recall of unlicensed TV band devices found to be causing interference.

C. It Will Also Be Difficult For The Commission To Prevent The Sale Of Illegal Devices And Aftermarket Accessories.

While the Commission's rules require unlicensed device certification and forbid the modification of such devices, the Commission will have limited capacity to prevent the internet sale of TV band devices and accessories that do not comport with the Commission's requirements.

By way of background, Section 15.203 of the Commission's rules require that a Part 15 unlicensed transmitter "shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device," and this section of the rules requires that the antenna must be "permanently attached" to the device or the device must use a "unique coupling" or connector for attaching the antenna to the device. In addition, Section 15.204 prohibits the use of external radio frequency amplifiers and antenna modifications. The intent of these rules is to prevent a user from increasing the interference potential of an unlicensed device, either by attaching a higher gain antenna to the device or by using an amplifier to increase the device's range.

A simple search of the internet, however, demonstrates the ineffectiveness of these rules. One web site (http://www.radiolabs.com) lists adapter cables for over 150 Wi-Fi devices made by over 35 different manufacturers that permit the connection of unapproved high gain antennas to these unlicensed devices.[61] This site also offers amplifiers to increase range, such as a device that claims to increase the power of the Apple Airport Wi-Fi system by a factor of 15 and

[61] *Available at* http://www.radiolabs.com/products/cables/cable.php (last visited Jan. 31, 2007).

activate the antenna jack so theoretically a user could attach an even higher gain unapproved antenna.[62] Another website (http://www.hyperlinktech.com) also lists Wi-Fi high gain antennas and amplifiers. A third site (http://www.ccrane.com/) offers both higher gain antennas[63] and illegal connectors.[64] These are just a few of the many examples of products intended to modify unlicensed devices.

The Commission must take note of the realities of the offerings on the Internet and the ease by which consumers may modify unlicensed devices to operate outside of the parameters allowed in the Commission's rules. In an unlicensed system, despite its best intentions the Commission will be generally incapable of policing these noncompliant devices.

D. The Commission Must Implement An Effective Enforcement Regime.

The Commission has had a longstanding, and legally required, obligation to protect incumbent licensed services from interference.[65] Therefore, in the unfortunate event that the Commission authorizes TV band devices to operate on an unlicensed basis in the band, it must implement an effective enforcement regime. As discussed above, once these devices are released into the market the Commission will have limited power to prevent interference through regulatory means. In the absence of a regulatory solution to the problems that arise after unlicensed devices are released into the market, the Commission must impose proper technical requirements.

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[62] *Available at* http://www.radiolabs.com/products/wireless/wireless-amplifiers.php (last visited Jan. 31, 2007).

[63] *Available at* http://www.ccrane.com/antennas/wifi-antennas/wifi-tabletop-antenna.aspx (last visited Jan. 31, 2007).

[64] *Available at* http://www.ccrane.com/antennas/wifi-antennas/versa-wifi-usb-adapter.aspx (last visited Jan. 31, 2007).

[65] *See* 47 U.S.C. §301; 47 C.F.R. § 15.5.

The FNPRM, however, fails to address any means by which the Commission might enforce the prohibition on unlicensed devices interfering with licensed services. At a minimum, the Commission should require TV band devices to be connected to the Internet and incorporate an automatic identification and shutoff function so that the device would cease operation if it is determined that it is creating interference. Successful development of such a technological enforcement regime, which requires further study and development, is essential to protect the public's over-the-air television service.

V. GIVEN THE MANY INTERFERENCE CONCERNS, AND THE LACK OF SUFFICIENT ENFORCEMENT MECHANISMS, THE COMMISSION SHOULD PROCEED CAUTIOUSLY WITH PROPOSALS TO ALLOW TV BAND DEVICES TO SHARE THE BROADCAST SPECTRUM.

In light of the severe interference that new TV band devices may cause to the viewing public, the Commission must proceed cautiously. At a minimum, certain safeguards and limits, as described more fully below, must be placed on any device that is allowed to operate in the television spectrum. These protections include an absolute prohibition on personal/portable devices, use of a robust and reliable geolocation method to keep TV band devices from operating in the protected contour of co-channel and adjacent-channel television stations, adoption of stricter out-of-band emission limits, and exclusive licensing of TV band devices. Further information about these protections, and the additional work needed to achieve them, is described below.

At the outset, the adoption of these baseline safeguards is fully consistent with the Commission's goal of providing new broadband services, especially to rural and underserved areas of the United States, [66] which MSTV and NAB fully support. Notably, it is through *fixed* broadband access that the Commission can further that goal; personal/portable devices will not

[66] *See* First R&O and FNPRM at ¶ 2.

deliver broadband access to rural families. If the Commission's proposal to allow TV band devices to operate in the spectrum is truly about solving the broadband problem in America, especially for rural areas, the Commission will be able to accomplish this goal by authorizing the operation of fixed devices while fully protecting the American public's over-the-air television service.

A. By Authorizing Only Fixed TV Band Devices To Operate, Accompanied By Proper Protections, The Commission Can Promote A Broadband Plan Without Endangering Television Reception.

MSTV and NAB understand that IEEE 802.22 will propose a fixed operation approach that incorporates key protections aimed at preventing the four types of interference discussed above in Section III. As a general matter, MSTV and NAB urge the Commission to formulate rules implementing IEEE 802.22's plan for fixed devices.

These protections should include a prohibition on the operation of devices within the contour of both co- and first adjacent channels. Such a prohibition can only be achieved through a rigorous combination of geolocation (using GPS), professional installation of the fixed TV band devices, *and* frequency sensing (which is utilized as an *added*, and not the sole protection, and which also would help prevent interference with cordless microphones).[67] To implement geolocation, the Commission must require fixed devices to utilize outdoor antennas, given that GPS is not reliable indoors.

Additional research and testing will be necessary to implement a geo-location protection system. Importantly, the key to geo-location is access to a reliable database. Thus, a correct, post-transition database will be necessary for all stations, including LPTV, translators and cable

[67] The current IEEE 802.22 approach specifically provides that the suggested -116 dBm sensing level assumes that there is no operation within both a television station's co- and adjacent channel, which is assured not through sensing, but through geo-location and professional installation.

head ends. While the Commission has proposed a final DTV Table, that table will continue to be revised up until the transition to DTV. Of course, there will also be ongoing changes in station parameters once the transition is complete, necessitating a means of keeping the database up to date. Moreover, the transition for Class A, LPTV and TV translator stations will not be completed by February 18, 2009. Accordingly, there may be considerable movement in channel use for several years after the transition and devices will have to protect both analog and digital operations of Class A, LPTV and TV translator operations during this period. As also discussed in Section III, proper out-of-band emission limits will need to be determined and adopted; the Part 15.209 emission limits are ineffective at preventing interference.

B. Personal/Portable Devices Are Not Compatible With Existing Operations In The Broadcast Spectrum.

The Commission's decision in this proceeding to permit only fixed low power devices to operate in the broadcast spectrum was certainly the proper course of action.[68] Personal/portable devices, defined as devices that operate independently of a base station, such as mesh networks, WiFi cards, etc, are extremely problematic and should not be allowed to operate in the television band because the Commission will be unable to ensure that harmful interference to licensed services does not occur.

Simply put, no method exists today (or in the foreseeable future) to prevent interference from personal/portable devices to consumers' reception of DTV services. For example, IEEE 802 has not conducted *any* studies on this issue, as it was beyond the scope of the Project Authorization Request which created the IEEE 802.22 Working Group, nor has any other IEEE 802 working group examined this issue. Therefore, there are currently no suggested rules for how portable/personal devices would be able to operate without causing harmful interference.

[68] *See* First R&O and FNPRM at ¶¶ 17-18.

As discussed above in Section III, MSTV's study showed there was significant co- and adjacent channel interference from personal/portable devices operating at 100 mW.[69] Sensing alone will be ineffective, as demonstrated, to prevent *any* devices (fixed or personal/portable) from operating within the protected contour of a co- or adjacent channel. But because of the limitations of GPS, the geolocation method proposed to keep fixed devices from operating within a station's co- or adjacent channel's contour does not work on indoor consumer devices. Once such operation occurs, it could prevent reception of DTV signals for miles. Out-of-band emissions would also have a serious effect on reception, as the personal/portable devices would often operate in very close proximity to consumers' television sets, in comparison to the outdoor operation of fixed devices.

Moreover, the enforcement problems described in Section IV would be particularly acute in the context of personal/portable devices. Wide diffusion of such devices is to be expected; just as today 2.4 GHz unlicensed devices can be found in many homes, personal/portable TV band devices could proliferate throughout neighborhoods and businesses. Unlike fixed devices, which would be professionally installed, there can be no reliable means of knowing where a personal/portable device ends up once it is sold to a consumer. The inability of the Commission to effectively oversee the proliferation of personal/portable devices will create greater economic incentives for manufacturers to make products that exceed the Commission's requirements, as occurred in the satellite radio space. Similarly, the abovementioned problems with aftermarket products designed to boost power will be even more profound.

In light of the unique and currently insurmountable challenges posed by the introduction of personal/portable devices into the broadcast spectrum, the Commission should not authorize

[69] *See* Exhibit A.

any such devices at this time. Risking the public's new digital television service to promote these devices would be particularly inappropriate given their lack of connection to the goal of improved broadband access, which can be achieved through careful introduction of *fixed* devices.

C. Only Exclusively Licensed TV Band Devices Should Be Allowed To Operate In The Broadcast Spectrum.

MSTV and NAB appreciate the Commission's willingness to consider the relative benefits of *licensed* uses of any "white spaces" that may exist.[70] The Commission has correctly recognized that an unlicensed system is not the only possible way to authorize spectrum sharing in the television spectrum. In fact, as discussed below, a licensed white space regime would carry numerous public interest benefits – accountability, efficiency, and public remuneration – that would be lost forever by an unlicensed devices regime. Depriving the public of the benefit of new, licensed spectrum is even more inappropriate given the large swaths of unlicensed spectrum that the Commission has made available on an unlicensed basis in recent years.

First, a licensed system would address one of the biggest problems with an unlicensed system: accountability. That is, if a device operating in licensed "white space" were to interfere with the public's access to free, over-the-air television, the licensee responsible for the spectrum used by that device could be identified and made accountable for remedying the problem. Assuming that some TV band devices will be allowed to operate within the broadcast spectrum, the only effective way to ensure that incumbent services will be protected is through a licensing system.

Second, a licensed system will also most efficiently make use of any available "white spaces" that may exist. Unlike an unlicensed regime, in which there is no mechanism to control the number of devices that operate simultaneously and the resulting "noise" from such operation,

[70] *See* First R&O and FNPRM at ¶¶ 26-32.

a licensed user has incentive to *decrease* noise so that the noise floor of the spectrum does not rise to harmful levels and thereby prevent the licensee's full exploitation of the "white spaces" spectrum. In contrast, in an unlicensed regime, manufacturers have incentive to maximize their use of the spectrum without concern to the aggregate effect on the white space at issue. This incentive results in a "tragedy of the commons" whereby noise from multiple unlicensed devices transmitting in the same spectrum with inefficient technology eventually degrades the ability of all users to benefit from the spectrum.[71] In licensed "white space," the same entity would control the spectrum used by television services and the TV band devices, and would consequently design all devices to operate using non-interfering technology.

Third, a licensed system benefits the economy and American taxpayers more effectively than an unlicensed system. With the adoption of Section 309(j) of the Communications Act, Congress made clear its intent that the Commission should auction new licenses for commercial use of the spectrum. Therefore, if TV band devices were to operate on a licensed basis, the Commission would auction licenses and receive revenues from the proceeds of the auction. In designing a system to auction new licenses for commercial use, Congress has asked the Commission to keep in mind, among others, the goals of "promoting economic opportunity" and "recovery for the public of a portion of the value of the public spectrum resource made available for commercials use and avoidance of unjust enrichment through the methods employed to award uses of that resource."[72]

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[71] On the unlicensed side, experience in the unlicensed 2.4 GHz band is instructive. There, cordless phones have "reap[ed] devastating effects on 802.11b WLANs" because the technologies used are not compatible for minimization of interference. *See Interference from Cordless Phones*, Wi-Fi Planet, April 15, 2003, *available at* http://www.wi-fiplanet.com/tutorials/article.php/2191241 (last visited Jan. 31, 2007).

[72] 47 U.S.C. §309(j).

The recent Advanced Wireless Services ("AWS") spectrum, which grossed $13.9 billion, speaks to the public benefits of licensing.[73] Moreover, the Congressional Budget Office has estimated that auction of television channels 52 through 69 will raise at least $10 billion[74]; auctioning of "white spaces" in channels 2 through 51 could produce similar results. These additional amounts would be lost, however, if the Commission chooses to allow TV band devices to operate in the broadcast spectrum on an unlicensed basis. These benefits to the economy and American taxpayers, lend further support to MSTV's position that licensing the television "white spaces," is the proper course of action.

Finally, the Commission should not allow unlicensed operation in the television band, and risk interference with licensed services, because the Commission has already provided adequate spectrum for the use of unlicensed devices. Within the so-called "beachfront" spectrum below 3 GHz, the Commission has already allocated over 100 MHz of spectrum to unlicensed uses. In addition, at the urging of unlicensed device manufacturers, the Commission in late 2003 expanded the Unlicensed National Information Infrastructure ("U-NII") band, which already had a 300 MHz-wide unlicensed allocation, by *255 MHz* of spectrum. As a result, unlicensed devices in the U-NII spectrum have access to 555 MHz of spectrum.[75] The Commission rightly

[73] *See* News Release, *FCC's Advanced Wireless Services (AWS) Spectrum Auction Concludes*, FCC (rel. Sep. 18, 2006).

[74] *See* Congressional Budget Office, Cost Estimate, Reconciliation Recommendations of the House Committee on Energy and Commerce, 12 (Oct. 31, 2005).

[75] Unlicensed devices may now operate in the following 5 GHz-band frequencies: 5.150-5.250 GHz, 5.250-5.350, 5.470-5.825. Thus, in the U-NII band alone, unlicensed devices have access to nearly twice the amount of spectrum that will be allocated to the public's free, over-the-air television service after the digital transition is complete.

characterized its decision to expand the U-NII band as "a significant increase in the spectrum available for unlicensed devices across the overall radio spectrum."[76]

Indeed, proponents of unlicensed devices appear to offer inconsistent rationales. The argument for using TV spectrum is that it has superior propagation characteristics. This would support using spectrum for unlicensed services, such as rural broadband, which can harness efficiencies of wide areas. In this regard, IEEE 802.22 has offered a fixed service approach to meet this need. However, the advantages of greater coverage are not needed for most personal and portable devices. For example, in-home wireless networking can utilize spectrum above 1 GHz to cover the short ranges typically needed for most home wireless network systems. In fact, such frequencies will be more efficient since they allow for greater frequency reuse. Thus the justification for using the TV band - greater propagation - seems to be lacking as applied to many personal and portable devices. Consequently, other bands, which do not have the risk of interference, would appear to be more appropriate.

In light of the overabundance of underutilized unlicensed spectrum, the Commission has no cause – even if it had the authority – to allow unlicensed devices to interfere with licensed services. Sufficient spectrum is available for new unlicensed services; the Commission need not put the public's licensed radiocommunications infrastructure at risk. The "white spaces" that exist in less densely populated areas should instead be auctioned on an exclusively licensed basis.

[76] News Release, *FCC Makes Additional Spectrum Available for Unlicensed Use*, FCC (rel. Nov. 13, 2003).

CONCLUSION

No less than the future of the public's television service is at stake in this proceeding. Accordingly, MSTV and NAB respectfully urge the Commission to adopt the above-described protections before authorizing any new devices in the broadcast spectrum.

Respectfully submitted,

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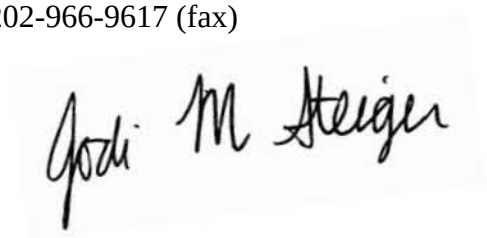

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January 31, 2007

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Before the

FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Unlicensed Operation in the TV Broadcast Bands	)	ET Docket No. 04-186
	)	
	)	ET Docket No. 02-380
Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band	)	

JOINT COMMENTS OF
THE ASSOCIATION FOR MAXIMUM SERVICE TELEVISION, INC.,
AND THE NATIONAL ASSOCIATION OF BROADCASTERS

The Association for Maximum Service Television, Inc. ("MSTV")[1] and the National Association of Broadcasters ("NAB")[2] file these comments in response to the Commission's *First Report and Order and Notice of Further Proposed Rulemaking* ("First R&O and FNPRM"). As discussed below, in order to avoid undoing the decades-long efforts at bringing the benefits of digital television ("DTV") to the American public, the regime under which *any* new devices are allowed into the broadcast spectrum *must* protect existing and future television and related licensed services from interference.[3] Any decision to permit new so-called

[1] MSTV is a non-profit trade association of local broadcast television stations committed to achieving and maintaining the highest technical quality for the local broadcast system.

[2] NAB is a nonprofit trade association that advocates on behalf of more than 8,300 free, local radio and television stations and also broadcast networks before Congress, the Federal Communications Commission and other federal agencies, and the Courts.

[3] Today, the TV spectrum is used by full power television stations, class A, low power television and TV translator stations to provide traditional local broadcast television services to the public. There are approximately 1,750 full service analog and digital television stations, over 500 class A stations, nearly 2,300 low power stations, and approximately 4,500 translator and booster stations. *See Broadcast Station Totals as of December 31, 2006*, News Release (rel. Jan. 26, 2007), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-269784A1.doc (last visited Jan. 31, 2007). The TV spectrum also supports vital broadcast auxiliary operations, such

EXHIBIT A

January 30, 2007

Analysis of Various Interference Mechanisms Affecting Television Reception from TV Band Devices

By Robert Eckert[1]

Introduction

This engineering statement has been prepared on behalf of the Association for Maximum Service Television ("MSTV") as part of its comments in response to the Commission's *First Report and Order and Notice of Further Proposed Rulemaking (Docket 04-168)* on Unlicensed Operation in the TV Broadcast Bands. Specifically, this statement addresses the types of interference that should be considered when developing technical rules to protect the existing licensed service from interference. The statement also provides a methodology to calculate interference and establishes minimum separation distances needed to protect TV reception from interference. The statement also finds that unlicensed devices in the TV bands, particularly personal/portable devices that are uncontrolled and can be located and operated anywhere, pose a significantly greater threat of interference to TV viewers. The statement also briefly describes the difficulty of co-channel sensing within a DTV station's contour.

I. Types of Interference

Interference to DTV reception can occur due to a number of different mechanisms. "TV band devices" and Part 15 unlicensed devices can not cause interference and must protect all TV operations against a number of different types of interference. Specifically, there are four basic types of interference such devices can cause to DTV receivers. They are: (1) co-channel interference; (2) adjacent channel interference; (3) out-of-band interference; and, (4) interference

[1] Robert Eckert is a recognized expert in the areas of propagation, radio communications and interference analysis. He has served as the Chief of the Technical Analysis Branch of the FCC's Office of Engineering and Technology and has done significant work in the area of digital television including the development of the FCC's DTV Table of Allotments.

from taboo channels and unwanted intermodulation products. A brief description of these various interference mechanisms and how they relate to TV band or unlicensed device operation are described below:

a. Co-channel Interference Considerations

Co-channel interference in the context of the DTV service comes from distant undesired signals of the same 6 MHz bandwidth as that of the desired signal. In the case of TV band devices, the Commission did not explicitly state in the instant rule making proceeding that the TV band or unlicensed device bandwidths would match that of the DTV service. However, it appears likely that unlicensed TV band devices will tend to use channels of about the same 6 MHz width as DTV and in a corresponding sequence.[2] It also appears that these devices will employ modulation techniques producing the same relatively flat and noise-like spectrum signature emitted by DTV transmitters. To the extent that emissions are similar, much of the testing and analysis that have generated protection requirements in the DTV service can be applied to determine requirements for low power TV band device or unlicensed operation.[3] In particular, after some prototype TV band devices become available and are tested, it may be found that the

[2] In the event the unlicensed device bandwidth is different than that of the DTV service or if the channels used by these devices do not coincide with those of the TV channels, the protection requirements included in FCC rules for the DTV service may have to be extended to include new desired to undesired (D/U) ratios for such operation.

[3] The DTV service was set up after comprehensive testing of prototype receivers to determine their robustness in the presence of various types of interference. Testing provided a quantitative measure of robustness as the ratio between desired and undesired signals at the point where degradation was first visible, the threshold of visibility. These ratios are incorporated in FCC rules in the particular cases of co-channel and adjacent channel interference, and further information is available in laboratory records of the testing effort. Though essential for establishing rules that might be established to govern manufacture and operation of unlicensed devices in the TV bands, these data may not be sufficient. This is due in part to the fact that the receivers tested were high quality prototypes and also because the tests did not include all types of interference that could be caused by unlicensed devices.

desired-to-undesired signal ratio adequate for co-channel DTV operation applies equally to DTV reception in the presence of co-channel signals from unlicensed or TV band devices. [4]

b. Adjacent Channel Interference Considerations

Adjacent channel interference poses a special problem for use of unlicensed devices in the TV bands. Just as in the DTV service, adjacent channel interference would come from undesired signals of equal bandwidth either immediately above or below the desired signal in frequency. In the case of operation of adjacent channels in the DTV service, the FCC established a DTV Table of Allotments that authorized adjacent channel operations at specific locations chosen to minimize interference throughout DTV stations' service areas. Such a methodology cannot be applied to TV band device or unlicensed device operation, where the location of such devices can not be precisely controlled. Calculations show that unlicensed transmitters or TV band devices of only 100 mW can produce a field strong enough to interfere with adjacent channel DTV receivers at 30 meters and beyond.[5] Therefore, the only safe approach is to preclude unlicensed devices from operating in adjacent channel DTV service areas. This means the "white space" for any particular channel excludes areas of adjacent channel DTV service as well as co-channel service areas. Allowance must be made for the possibility that the device is being used at a point where the signal of an active DTV station on an adjacent channel is weak. This weak signal condition is expected near the edge of DTV service areas but may also occur well inside due to shadowing. Consequently, the proposed Part 15 rules for unlicensed rules must define an available channel as

[4] As noted above, some additional testing should be carried out to ensure that the DTV D/U ratios apply to TV band devices that employ different modulation techniques. Alternatively, it would be appropriate to include some additional margin to take into account differences between DTV ATSC signals and other signal modulations such as COFDM or QPSK that may be used by these TV band devices.

[5] In weak DTV signal situations this distance can be hundreds of meters. See the Table of Distances to Various Field Strengths, in Section II-a of this paper. Also see MSTV/NAB comments for calculation of adjacent channel interference distances.

one distant from both co- and adjacent channel of a DTV station, i.e., outside the TV station's contour by some appropriate distance.[6]

c. Out-of Band Emission Interference Considerations

Emissions adjacent to each side of the operating 6 MHz channel are not ordinary out-of-band emissions to be treated as haphazard unintentional radiation. Instead, the rules in Section 15.209 must explicitly recognize the limited (120 kHz) bandwidth of CISPR quasi-peak measurements of out-of-band emissions. Supposing that the CISPR measurement is reasonably accurate in determining the power of noise-like signals in 120 kHz, the total power in a flat noise-like signal of 6 MHz is 17 dB greater, and that is a key parameter in determining the potential for out-of band channel interference.[7] Measurement procedures by whatever means should obtain all the significant data that could be obtained using a spectrum analyzer.

In addition, the total power in a wide range of frequencies in the vicinity of a consumer's TV reception system will generally increase the noise level, affecting channels beyond the first adjacency. This is particularly applicable to situations involving many unlicensed transmitters, especially in view of the envisioned popularity of the personal/portable TV band devices being proposed. By itself, this factor could wipe out DTV service on channels that might otherwise be considered unaffected. The possibilities for apparent noise power accumulation over many frequencies from many locations should be considered in revising the rules for out-of band emissions in Section 15.209. Limits should be established so that the results of allowing

[6] The required separation distances are calculated later in this paper.

[7] The effects of operation on an adjacent channel are two-fold: First, receivers are unavoidably sensitive to power that may be present in the adjacent frequency space; and second, a modulated signal in the adjacent channel will inevitably spill some power into the desired channel. The second of these effects is measurable with a spectrum analyzer, while the combined effect of the two factors is measured in terms of the desired-to-undesired signal ratio at which the DTV picture is lost.

unlicensed devises in the TV bands can be monitored in terms of the number and location of devices.

d. Intermodulation Interference Considerations

Interference potentially harmful to DTV reception can also arise due to *intermodulation* between various signals, weak and strong both within and outside the desired DTV channel, that may be presented to DTV receivers. Interference of this type occurs in the receiver itself, and is more likely in DTV receivers sold today than in the high quality prototype DTV receivers used to develop the DTV planning factors. For example, an image of an otherwise ignorable first-, second-, or third-adjacent DTV channel can be made to fall on the desired signal by intermodulation with narrow band spurious emissions by unlicensed devices. While intermodulation is almost certainly present in real situations, the effects on DTV receivers have not been tested in a way that could lead to quantitative criteria for interference protection.[8] Some new information in this regard is available from recent tests conducted by the CRC and additional information may become available because the Commission has directed its laboratory to test contemporary DTV receivers with interfering signals from second- and third-adjacent channels and beyond.[9] These projects offer a good opportunity for an investigation that might at least set some bounds on the degree of desensitization that can be caused by intermodulation in real situations. Such real situations involving DTV transmissions alone exist today. If it is found likely that appreciable interference is created by this mechanism, it will be necessary to design special restrictions on the use of unlicensed devices to eliminate this type of interference.

[8] The early comprehensive testing, upon which FCC rules for DTV service are based, examined co-channel interference, adjacent channel interference, man-made noise, and narrow-band emissions of the kind produced by land mobile transmitters. The interference sources for co-channel testing were DTV emissions confined to 6 MHz. The sources for adjacent channel testing were similar DTV emissions confined to the 6 MHz exactly neighboring the desired channel below and, separately, above in frequency. Thus there is a lack of data for conclusively determining the effects of emissions outside of first-adjacent DTV channels and of their effects when combined with first-adjacent channels themselves.

[9] At the request of MSTV, The CRC laboratory has recently conducted such tests.

II. White Space and Protection Ratios

Assuming that the transmissions of unlicensed TV band devices will have a spectrum signature very much like that of DTV, many of the quantitative criteria used for the mutual protection of DTV stations can be applied to the introduction of unlicensed devices. These quantitative criteria are found in the subpart of FCC Rules governing Television Broadcast Stations.[10] The rules in that subpart place limitations on transmitting facilities and specify the locations where specific channels are assigned or available. Similar rules of a quantitative nature must be created for unlicensed devices if they are allowed in TV bands. This entails defining boundaries of the "white space" available for use of specific channels and the technical characteristics of devices that will be allowed on such channels.

To get a clear idea of how unlicensed devices may be used, it is helpful to analyze the process of determining white space. A determination based on the protection ratios established in FCC Rules at §73.623(c) will tend to make unlicensed use conform to the protection rules already established for the DTV service itself. There are two elements to this determination: first the service contours of individual stations, and second the distance that must be maintained between unlicensed devices and TV receivers that may be located on the service contour.

Assuming that TV band devices are allowed to operate wherever they do not cause interference with either co-channel or adjacent channel TV service (as stated previously, operation of such TV band devices is not feasible within the co-channel or adjacent channel TV service area), the following procedure is necessary to determine whether a particular channel is available at a particular geographical point. Presumably the determination would be made with computer assistance. A table is prepared of the separation distances between the point of interest and the

[10] Code of Federal Regulations, Part 73, Subpart E, entitled Television Broadcast Stations.

service contour of every co-channel and adjacent channel DTV station.[11,12] The smallest of these distances is examined, separately, for each of the adjacent channels and for the candidate unlicensed device channel. All three of these distances must of course be positive; that is, the point of interest must lie outside all service contours of any of the three channel types, co-channel, lower adjacent and upper adjacent.[13,14] Finally, protection ratios and power limitations imposed on unlicensed devices determine whether the device is far enough from TV receivers that may be located on these service contours. It is not enough, for example, that the candidate unlicensed device channel is assigned to serve Baltimore or Annapolis when proposing use of unlicensed operation in Washington, DC. The possibility of an error of this kind indicates the importance of establishing rigorous procedures for creating channel availability tables for unlicensed devises.

To align with the rules governing DTV service, minimum distances to service contours should be determined by reference to the D/U ratios of §73.623(c).[15] These D/U ratios are –28 dB and –26

[11] The service contour is the outer boundary of the area in which the predicted F(50, 90) field strength is the value given in § 73.622(e). For the UHF band the value is 41 dBu. This value may be subject to a modification by what is called the "dipole factor" dependent upon the specific UHF channel of interest. Whether to apply this modification is a detail that must be addressed by FCC rules for unlicensed devices. The F(50, 90) field is predicted based on TV transmitter power, antenna height and horizontal antenna gain pattern.

[12] Note that it must be decided whether the database from which the table is prepared will contain engineering parameters of stations as currently licensed or maximum facility parameters.

[13] Note that more than just one upper and one lower adjacent channel service area may be near a particular point of interest. The situation can be quite complicated in urban areas.

[14] Some proponents of unlicensed TV band devices will argue for ignoring possibilities for interference on adjacent channels despite computations showing that interference of this kind can occur at significant distances, *e.g.* beyond 30 meters for a 100 mW device, and beyond a kilometer in the case of a 1 watt device.

[15] It is intended that the desired (D) and undesired (U) signals be evaluated as received through directional receiving antennas, and therefore authorization of unlicensed devices requires a model of the orientation of receiving antennas. Planning factors for the DTV service lead to a determination that the field of 41 dBu in the receiver's neighborhood is adequate for reception provided that the receiving antenna has a forward gain of 10 dB. It is assumed that the receiving antenna in fact achieves this gain by being pointed at the

dB respectively for interference from lower and upper adjacent channels. In the case of the lower adjacent channel, for example, this means that interference is considered to occur at the service contour when the undesired signal is more than 28 dB stronger than 41 dBu. Note that these considerations involve a considerable degree of precision, attainable for operation of unlicensed devices at fixed locations, but requiring an extra margin of decibels in case sensing alone is relied upon by smart devices.

The criteria for co-channel operation are different in nature because any small co-channel signal power will overwhelm receivers located at the service contour. In the DTV service and interference model on which §73.623(c) is based, co-channel emissions of almost any magnitude raise the noise level sensed by receivers at the service contour to a value exceeding the minimum signal-to-noise requirement. The DTV picture will abruptly at that point be lost.[16] Therefore unlicensed devices operating co-channel must be completely out of range, and the out-of-range distance should be conservatively chosen to prevent interference possibilities.

a. Required Separation Beyond Service Contours

Consider the following situation. An unlicensed TV band device is at a geographical point determined to be outside the noise-limited service contour of a particular DTV station. The device must also be so far out of range that its co-channel emission does not increase the apparent receiver noise level. Refer to the table of distances to various field strengths, below. According to the table, to keep the free space interference field 20 dB below the desired DTV signal would require a separation of 600 miles even though 20 dB is nowhere near enough. It is obvious that

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desired station. However, it cannot be safely assumed that undesired signals from unlicensed devices would reach receiving antennas from a low gain direction.

[16] Section §73.623(c) sets the level at which this happens at 23 dB below the desired 41 dBu signal. This is a noise level 7 dB weaker than the level in the absence of interference and is deemed ignorable.

obstacles on the horizon would normally provide an effective shield, and a lesser distance will be adequate. Radio propagation models like those used to calculate contour distances could be used. However, those models involve statistical concepts such as percentage of location and time, are not well supported by data except at confidence limits near 50%, and are inappropriate in the present application where confidence approaching 100% is needed. A practical separation requirement must nevertheless be established, and it makes good sense to base this on line-of-sight considerations. The line-of-sight distance between antennas both at rooftop height is about 15 miles, and the distance from a hand-held device to a rooftop antenna is about 10 miles.[17] Assuming that the device is 15 miles outside all co-channel DTV service contours, a further check must be made to protect adjacent channel DTV. FCC rules at §73.623(c) indicate that DTV stations are protecting one another's service provided that adjacent channel fields are less than 67 dBu and 69 dBu respectively for interference from lower and upper adjacent channels.[18] From the table of distances to various field strengths, it is found that this level of protection will be achieved by requiring that 4 Watt EIRP devices stay at least 3 miles from the contour of an adjacent channel TV station.

[17] These values are the respective sums of the distances from the common horizon.

[18] The 69 dBu number comes from adding 28 dB to the field of 41 dBu that defines noise-limited contours. Similarly, 67 dBu is the sum of 41 dBu and the 26 dB required for upper adjacent protection.

DISTANCE TO VARIOUS FIELD STRENGTHS BY FREE SPACE PROPAGATION						
Field Near TV Receiving Antenna			Distance from isotropically radiated power of 4 Watts			Significance Of this Field Strength Value
dBu	microvolts/m	Volts/m	m	km	miles	
21	11.2	1.12E-06	976316	976	607	20 dB below the smallest DTV signal that will provide a picture at the noise-limited contour.
41	112.2	0.000112	97632	97.6	60.7	41 dBu is the smallest DTV signal that will provide a picture at the noise-limited contour.
67	2238.7	0.00224	4893	4.89	3.04	Maximum field from DTV transmitter on upper adjacent channel that does not cause interference
69	2818.4	0.00282	3887	3.89	2.42	Maximum field from DTV transmitter on lower adjacent channel that does not cause interference

b. Calculating Interference

The table below describes a procedure for calculating the interfering power that would be produced by RF sources in the TV bands. The effects indicated in steps 5, 6 and 7 assume that the interference power is noise-like with an approximately flat spectrum over 6 MHz.

Note that interference fields produced by 4 W or 4000 mW sources are very great. One consequence of this is that such sources must be located well outside the service contours of both co-channel and adjacent channel DTV stations.

Also note that even though a device may be outside co- and adjacent channel contours, it will almost certainly be inside the contour of one or more DTV stations, specifically those using channels removed by 12 or more MHz. Inside DTV service contours the directionality of TV receiving systems is irrelevant and no amount of cross-polarization discrimination is reliable. Moreover, the out-of-band emission mask applied to unlicensed devices (by revising Section

15.209) must limit power outside the co- and adjacent channels to especially small values. *The table shows that power over every 6 MHz portion of the TV band should be considerably less than 9.5E-7 mW except for the 6 MHz used by the device and the two adjacent channels.*

INTERFERENCE CALCULATIONS					
STEP	PROCEDURE	EXAMPLES			
		3 m from source	10 m from source	3 m from source	10 m from source
1	Start with the isotropically radiated power of the source.	4000 mW	4000 mW	9.50E-7 mW	9.50E-7 mW
2	Calculate Power Flux Density (PFD): The surface area of the sphere 3 m from the source is 4*pi*3*3 = 113 sq. m, so the PFD for 4000 mW is 4000/113 mW/sq. m. At 10 m from the source the surface area is 4*pi*10*10 = 1257 sq. m.	35.4 mW/sq. m	3.18 mW/sq. m	8.41E-09 mW/sq. m	7.56E-10 mW/sq. m
3	Find field from PFD: Convert the PFD to watts/sq. m, multiply by the resistance of free space (377 ohms), then take the square root. The result is the field in V/m.	3.65 V/m	1.095 V/m	0.0000563 V/m	0.0000169 V/m
4	Convert V/m to conventional units describing the field: 20*log(V/m) +120 = dBu. This is the interference field.	131.2 dBu	120.8 dBu	35.0 dBu	24.5 dBu
5	Find C/I, the excess of field required for DTV reception over the interference field: The required DTV field is nominally 41 dBu (OET Bulletin No. 69 shows how this value is modified by the dipole reception factor for various channels).	-90.2 dB	-79.8 dB	6.0 dB	16.5 dB
6	Find I/N, the ratio of interference power to the thermal noise experienced by DTV receivers near 41 dBu contours: I/N = 15 - C/I (15 dB is the minimum carrier-to-noise ratio for DTV reception)	105.2 dB	64.8 dB	9.0 dB	-1.5 dB
7	Evaluate potential for interference: I/N should be negative. A value of 0 dB effectively doubles the noise experienced by the receiver so that minimum DTV signal is 44 dBu (an increase of 3 dB).	loss of picture	loss of picture	loss of picture except where DTV signal is very strong	DTV receiver is desensitized by less than 3 dB.

III. Sensing

The sensing of RF fields is an inadequate means for protection of DTV services. These services require protection based on service contours determined in an absolute way, by reference to geographic information and precise knowledge of the location of unlicensed devices before they transmit. Sensing, however, is only capable of measuring RF fields in a very localized way, at a moment in time, at a particular point among or inside buildings, and at a particular height relative to building heights and terrain.

Since sensing cannot be used to determine where a device is located in reference to contours, it could at best be effective for devices whose power is so small as to be safe within a very limited area around it. Moreover, a network of devices is impractical since this same area confines the entire network. In such a small area there may be some assurance that no DTV receivers are able to get a picture so that the device could transmit without interrupting DTV service. However, very little confidence can be placed in measurement by a single sensing device of a short duration. According to an analysis of the Canadian Research Center, there is a margin of only 24 dB between the threshold of feasible sensing technology and the minimum field required by DTV receivers.[19] Thus, an incorrect clear-to-transmit decision will be made whenever the signal that happens to be available to the sensing device is 24 dB less than the field in use by DTV receivers.

Signal variation of 24 dB is highly likely due solely to the statistics of RF propagation. Location variability in the UHF TV band is in the order of 15 dB, and the motion of vehicles in the vicinity and the way mobile devices are held can make another 10 dB difference. The factors just

[19] Sensing Parameters: Estimates and Analysis, Gerald Chouinard, CRC, Canada, found at http://www.eecs.berkeley.edu/~dtse/3r_notor.ppt. This paper assumes a sensing level of -116 dBm, and that both the TV receive antenna and the IEEE unlicensed fixed device sensing antenna are located at 30 feet above ground so that there is no height difference between the TV receive antenna and the sensing antenna. The -116 dBm is the same level suggested by the FCC for a 4 Watt TV band device. Sensing at the -116 dBm level, however, is not used by the IEEE to ensure that the unlicensed fixed is located a sufficient distance outside a TV station's co- and adjacent channel contour.

mentioned are just the statistical uncertainties. In addition there is the "hidden node" problem in which an obstacle that is not part of the propagation path for local DTV reception nevertheless blocks the path to a sensing device.

IV. Conclusions

To ensure that TV band devices provide at least the same level of protection as TV licensees receive from other licensed operations, co-channel and adjacent channel operation of such devices must be prohibited inside the DTV service contours. In addition, specific separation or "keep away" distances from those contours must be established, and it would be reasonable and practical to base these keep-away distances on free space radio path loss calculations and line-of-sight considerations.

Revision of §15.209 of FCC Rules for unlicensed TV band devices must require that out-of-band noise power over every 6 MHz portion of the TV band be considerably less than 9.5E-7 mW except for the 6 MHz used by the device and the two adjacent channels.[20] The "white space" in the TV band is much more limited than implied by mere consideration of co- and adjacent channel interference. This is because almost any point on the map is covered by one or more DTV services that can be desensitized by noise-like emissions to the point of losing picture.

Finally, sensing is an ineffective method for protecting DTV service from interference, especially in the case of personal/portable devices. The radio fields observed by sensing devices are subject to variations considerably larger than the detection window of practical devices.

[20] This presumes that that co- and adjacent channel operation within the TV station contour is prohibited.

EXHIBIT B

Communications Research Centre Canada
An Agency of Industry Canada
Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

LABORATORY EVALUATION OF FIVE VSB TELEVISION RECEIVERS IN DTV ADJACENT CHANNEL INTERFERENCE

LABORATORY TEST REPORT AND CALCULATIONS

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Report Intended for:
The Association for Maximum Service Television, Inc. (MSTV)

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Contents

1 Introduction

The Association for Maximum Service Television, Inc. (MSTV) requested laboratory evaluation of five ATSC 8-VSB digital television receivers in the presence of adjacent/taboo DTV channel interferences. The receivers were tested in the laboratory of the Communications Research Centre Canada to determine their capabilities to receive DTV signals in the presence of a single or multiple DTV interferers. These interference signals were intended to simulate conditions expected to be found when operating unlicensed devices in the TV band pursuant the FCC proposal in Docket 04-168. The tests were carried out in January 2007.

2 Major findings

The major findings of the laboratory test can be summarized as:

- There can be substantial differences in interference performance of different VSB receivers and interference mechanisms, regardless of age and vintage.
- Interfering signals on the upper and lower first adjacent channel are the most problematic and consistently result in large calculated interference distances “r” at which the interfering device can cause a DTV receiver to reach TOV.
- In general, interfering signals on the second and third adjacent channels can also be problematic and result in calculated interference distances “r” larger than 10 meters.
- Image interference on channels +7, +14 and +15 can also result at significant distances under certain circumstances for certain receivers.
- Multiple interfering signals reduce the D/U ratios. The worst case appears to be N+x and N+2x. Degradation of more than 30 dB and more have been measured on some receivers.

3 Laboratory Set-up and Test Conditions

The VSB receivers were tested against DTV interferences. The tests included adjacent/taboo channels interference from N – 15 to N + 15 into DTV.

3.1 Laboratory Evaluation Set-up

The laboratory set-up for the evaluation of the VSB receivers is presented in figure 1. The set-up is divided in three sections: Transmitter, Channel and Receiver.

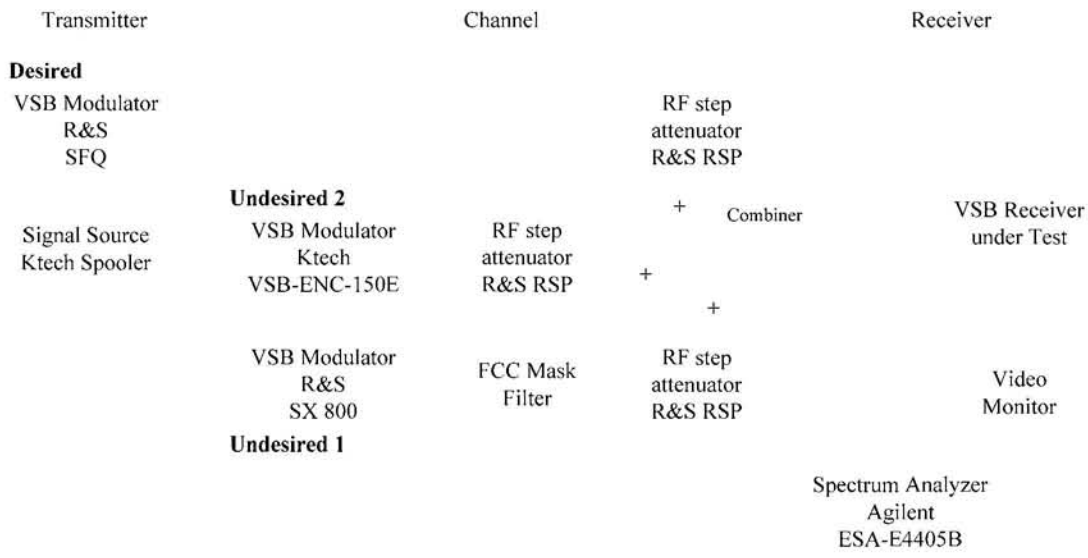


Figure 1 – Laboratory Equipment set-up

3.1.1 Transmitter

The **Desired** 8-VSB signal was obtained from a Rohde & Schwarz SFQ modulator. The signal source for the 8-VSB modulator was from a video spooler.

3.1.2 Channel

The **Undesired 1** DTV signal came from a R&S SX 800 VSB modulator, the RF output was connected to a high precision attenuator through a FCC Mask compliant filter. This DTV signal has a fix channel output, 662-668 MHz, channel 46.

The **Undesired 2** DTV signal came from a Ktech VSB-ENC-150E VSB modulator, the RF output was directly connected to a high precision attenuator.

An Agilent ESA-E4405B spectrum analyzer was connected at the combiner output, to make the average power measurement of the DTV signals.

3.1.3 Receiver

The output signal from the combiner was connected to the 8-VSB receiver under test.

The video signal from the integrated MPEG decoder was connected to a video monitor to determine the Threshold of Visibility (TOV) level.

3.1.4 Test Conditions

The tests were done from channel 17 to 61, depending of the test scenario.

Five different receivers were used and two scenarios for single DTV into DTV were tested.

The first scenario: the desired DTV signal was fixed on channel 32 and the undesired DTV channel was changed from channel 17 to 47 (N-15 to N+15). The undesired signal (See description of **Undesired 2** above) was **not filtered**.

The second scenario: the desired DTV channel was changed from channel 31 to 61 (N+15 to N-15) and the undesired DTV signal was fixed on channel 46. The undesired signal was **filtered** according to FCC mask specifications. (See description of **Undesired 1** above)

TOV was found over a 15 seconds measurement period. A delay of 5 seconds was granted to the receiver for stabilization before the TOV measurement was started. TOV is the point where you first encounter visual errors (such as blocking or freezing) on the picture over the measurement period with the minimum level of interferences. The precision of the test was 0.5 dB.

4 Test Procedures and Results

The following procedures were intended to verify the performance of five 8-VSB receivers under DTV into DTV. These tests included the following measurements:

a. Single interferer
- Single Unfiltered Adjacent DTV from N-15 to N+15 into DTV;
- Single Filtered Adjacent DTV from N-15 into N+15 into DTV;

b. Multiple interferers
- N-1 and N+1 into DTV;
- N-2 and N+2 into DTV;
- N-3 and N+3 into DTV;
- N-4 and N+3 into DTV;
- N+2 and N+3 into DTV;
- N+2 and N+4 into DTV;
- N+4 and N+6 into DTV;
- N+7 and N+14 into DTV.

4.1 Results for Single DTV Interference into DTV

The purpose of this test was to determine the performance of the 8-VSB receivers under the case of a single adjacent or taboo channel interfering signal.

The level of interference (D/U) at TOV was recorded for an undesired DTV signal. These tests were done with the following five different desired DTV signal RF levels:

- Very Strong: -15 dBm
- ATSC Strong: -28 dBm
- ATSC Moderate: -53 dBm
- ATSC Weak: -68 dBm
- 7 dB above Edge of DTV Contour : -76 dBm

NOTE: The ATSC specified DTV receiver min. signal level is -83 dBm, which is the signal received at the Edge of the DTV coverage contour. At min. signal level, the receiver cannot tolerate any additional impairment. The desired signal level used in the laboratory test must be higher than the min. signal level. Some legacy receivers can not meet the ATSC min. signal level specification. A head room of 7 dB was added to the min. signal level, i.e. -76 dBm, as the lowest desired signal level in order to overcome the difference in minimum threshold levels between receivers. Note however that the lower the desired signal, the more sensitive the receiver to the impairments.

Table 1 to 5 shows the result for **Unfiltered DTV into DTV** with five desired powers. In that case, the desired DTV signal was fixed on channel 32 and the undesired DTV signal (unfiltered) was set to the proper channel relationship.

Table 6 to 10 shows the result for **Filtered DTV into DTV** with five desired powers. In that case, the undesired DTV signal was fix on channel 46, filtered according to FCC mask, and the desired DTV signal was set to the proper channel.

Graphs for Moderate, Weak and 7 dB above Edge of DTV Contour for Unfiltered and Filtered DTV into DTV are presented following the corresponding table.

NOTE: 1. Table cells highlighted in YELLOW mean that the maximum power level generated from the test bed configuration was reached. The actual D/U ratios highlighted in yellow in the table are less than the reported value. In those cases, TOV was never reached that there was no video impairment.
2. Table cells highlighted in RED mean that the receiver failed to acquire at that desired signal level without the interference (the receiver min. signal level is too high on this RF channel).

Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
-15 dBm	N-15	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	1.3	-16.3
-15 dBm	N-14	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	1.3	-16.3
-15 dBm	N-13	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	2.3	-17.3
-15 dBm	N-12	>5.9	<-20.9	>5.9	<-20.9	>5.9	<-20.9	>5.9	<-20.9	2.4	-17.4
-15 dBm	N-11	>5.9	<-20.9	>5.9	<-20.9	>5.9	<-20.9	>5.9	<-20.9	2.9	-17.9
-15 dBm	N-10	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	1.8	-16.8
-15 dBm	N-9	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	>5.8	<-20.8	2.3	-17.3
-15 dBm	N-8	>5.6	<-20.6	>5.6	<-20.6	>5.6	<-20.6	>5.6	<-20.6	1.6	-16.6
-15 dBm	N-7	>5.6	<-20.6	>5.6	<-20.6	>5.6	<-20.6	>5.6	<-20.6	2.1	-17.1
-15 dBm	N-6	>5.7	<-20.7	>5.7	<-20.7	>5.7	<-20.7	>5.7	<-20.7	2.2	-17.2
-15 dBm	N-5	>5.5	<-20.5	>5.5	<-20.5	>5.5	<-20.5	>5.5	<-20.5	1.5	-16.5
-15 dBm	N-4	>5.7	<-20.7	>5.7	<-20.7	>5.7	<-20.7	>5.7	<-20.7	2.2	-17.2
-15 dBm	N-3	>5.6	<-20.6	>5.6	<-20.6	>5.6	<-20.6	>5.6	<-20.6	2.6	-17.6
-15 dBm	N-2	>5.7	<-20.7	>5.7	<-20.7	>5.7	<-20.7	>5.7	<-20.7	2.7	-17.7
-15 dBm	N-1	>6.7	<-21.7	2.2	-17.2	1.7	-16.7	2.2	-17.2	0.2	-15.2
-15 dBm	N+1	>6.5	<-21.5	3.0	-18.0	0.5	-15.5	3.5	-18.5	0.5	-15.5
-15 dBm	N+2	>6.7	<-21.7	>6.7	<-21.7	6.2	-21.2	>6.7	<-21.7	2.7	-17.7
-15 dBm	N+3	>6.7	<-21.7	>6.7	<-21.7	>6.7	<-21.7	>6.7	<-21.7	2.2	-17.2
-15 dBm	N+4	>6.8	<-21.8	>6.8	<-21.8	>6.8	<-21.8	>6.8	<-21.8	2.3	-17.3
-15 dBm	N+5	>6.9	<-21.9	>6.9	<-21.9	>6.9	<-21.9	>6.9	<-21.9	1.9	-16.9
-15 dBm	N+6	>6.9	<-21.9	>6.9	<-21.9	>6.9	<-21.9	>6.9	<-21.9	1.9	-16.9
-15 dBm	N+7	>6.9	<-21.9	>6.9	<-21.9	-3.1	-11.9	>6.9	<-21.9	1.9	-16.9
-15 dBm	N+8	>7.0	<-22.0	>7.0	<-22.0	>7.0	<-22.0	>7.0	<-22.0	2.0	-17.0
-15 dBm	N+9	>7.0	<-22.0	>7.0	<-22.0	>7.0	<-22.0	>7.0	<-22.0	2.0	-17.0
-15 dBm	N+10	>7.2	<-22.2	>7.2	<-22.2	>7.2	<-22.2	>7.2	<-22.2	2.2	-17.2
-15 dBm	N+11	>7.1	<-22.1	>7.1	<-22.1	>7.1	<-22.1	>7.1	<-22.1	2.1	-17.1
-15 dBm	N+12	>7.1	<-22.1	>7.1	<-22.1	>7.1	<-22.1	>7.1	<-22.1	1.6	-16.6
-15 dBm	N+13	>7.3	<-22.3	>7.3	<-22.3	>7.3	<-22.3	>7.3	<-22.3	1.8	-16.8
-15 dBm	N+14	>7.6	<-22.6	>7.6	<-22.6	>7.6	<-22.6	>7.6	<-22.6	2.1	-17.1
-15 dBm	N+15	>7.6	<-22.6	>7.6	<-22.6	>7.6	<-22.6	>7.6	<-22.6	1.6	-16.6

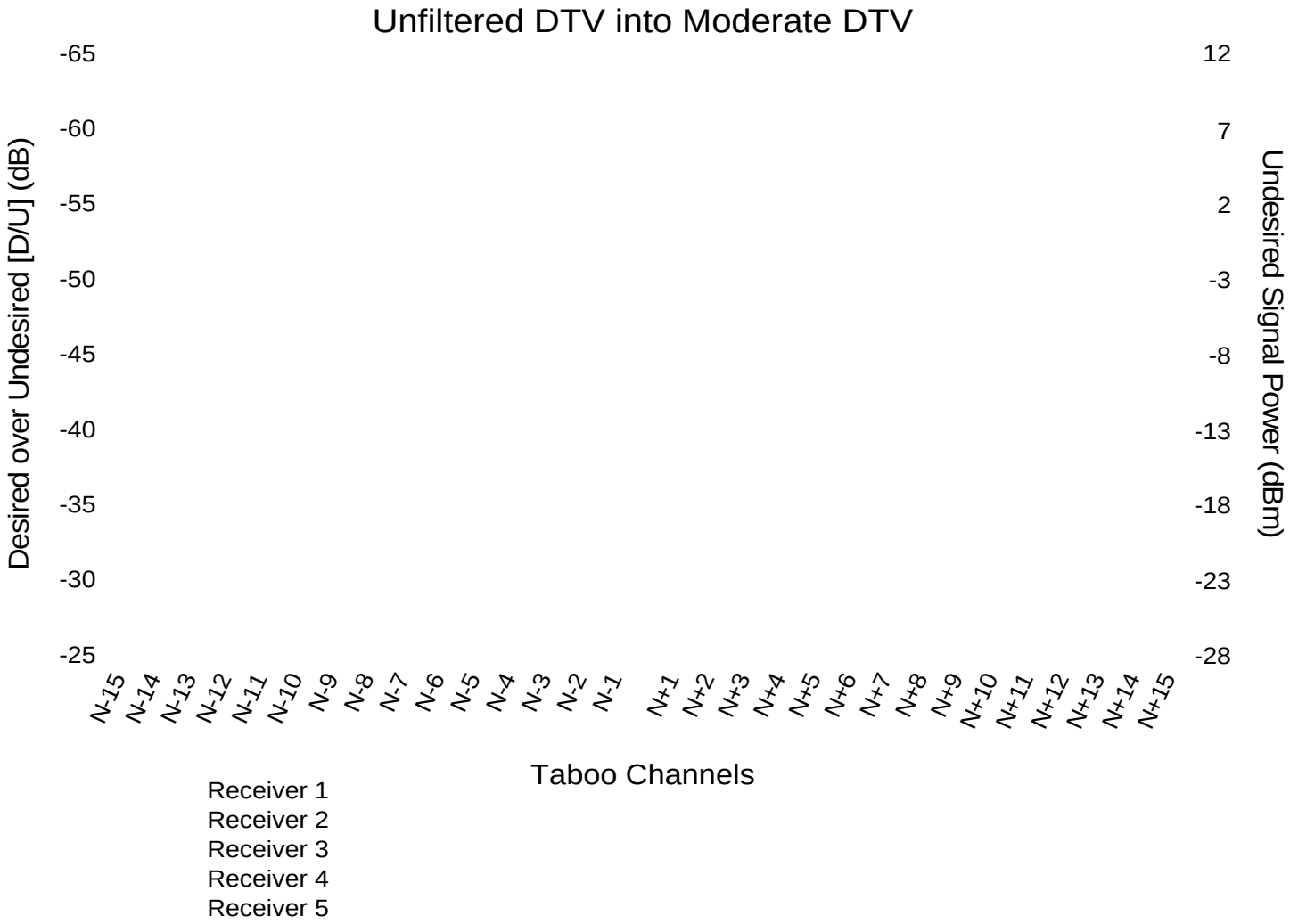
Table 1 – Unfiltered DTV Interference into Very Strong DTV (-15 dBm)

Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Strong	N-15	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	1.3	-29.3
Strong	N-14	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	1.8	-29.8
Strong	N-13	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	2.3	-30.3
Strong	N-12	>5.9	<-33.9	>5.9	<-33.9	>5.9	<-33.9	>5.9	<-33.9	2.9	-30.9
Strong	N-11	>5.9	<-33.9	>5.9	<-33.9	>5.9	<-33.9	>5.9	<-33.9	3.9	-31.9
Strong	N-10	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	2.8	-30.8
Strong	N-9	>5.8	<-33.8	>5.8	<-33.8	>5.8	<-33.8	4.3	-32.3	3.3	-31.3
Strong	N-8	>5.6	<-33.6	>5.6	<-33.6	>5.6	<-33.6	3.1	-31.1	2.6	-30.6
Strong	N-7	>5.6	<-33.6	>5.6	<-33.6	>5.6	<-33.6	0.1	-28.1	3.6	-31.6
Strong	N-6	>5.7	<-33.7	>5.7	<-33.7	>5.7	<-33.7	-0.8	-27.2	3.7	-31.7
Strong	N-5	>5.5	<-33.5	>5.5	<-33.5	>5.5	<-33.5	-1.0	-27.0	2.5	-30.5
Strong	N-4	>5.7	<-33.7	>5.7	<-33.7	>5.7	<-33.7	>5.7	<-33.7	2.2	-30.2
Strong	N-3	>5.6	<-33.6	>5.6	<-33.6	5.1	-33.1	>5.6	<-33.6	2.1	-30.1
Strong	N-2	>5.7	<-33.7	>5.7	<-33.7	>5.7	<-33.7	>5.7	<-33.7	1.7	-29.7
Strong	N-1	1.2	-29.2	-0.8	-27.2	-1.8	-26.2	-0.3	-27.7	-2.8	-25.2
Strong	N+1	-1.0	-27.0	0.5	-28.5	-3.0	-25.0	1.0	-29	-2.0	-26.0
Strong	N+2	>6.7	<-34.7	>6.7	<-34.7	5.7	-33.7	>6.7	<-34.7	1.7	-29.7
Strong	N+3	>6.7	<-34.7	>6.7	<-34.7	6.2	-34.2	6.2	-34.2	2.2	-30.2
Strong	N+4	>6.8	<-34.8	>6.8	<-34.8	5.8	-33.8	>6.8	<-34.8	3.3	-31.3
Strong	N+5	>6.9	<-34.9	>6.9	<-34.9	5.4	-33.4	>6.9	<-34.9	4.4	-32.4
Strong	N+6	>6.9	<-34.9	>6.9	<-34.9	>6.9	<-34.9	>6.9	<-34.9	4.4	-32.4
Strong	N+7	>6.9	<-34.9	>6.9	<-34.9	-3.6	-24.4	>6.9	<-34.9	3.9	-31.9
Strong	N+8	>7.0	<-35.0	>7.0	<-35.0	>7.0	<-35.0	>7.0	<-35.0	3.5	-31.5
Strong	N+9	>7.0	<-35.0	>7.0	<-35.0	>7.0	<-35.0	>7.0	<-35.0	2.5	-30.5
Strong	N+10	>7.2	<-35.2	>7.2	<-35.2	>7.2	<-35.2	>7.2	<-35.2	3.2	-31.2
Strong	N+11	>7.1	<-35.1	>7.1	<-35.1	>7.1	<-35.1	>7.1	<-35.1	3.1	-31.1
Strong	N+12	>7.1	<-35.1	>7.1	<-35.1	>7.1	<-35.1	>7.1	<-35.1	2.6	-30.6
Strong	N+13	>7.3	<-35.3	>7.3	<-35.3	>7.3	<-35.3	>7.3	<-35.3	2.8	-30.8
Strong	N+14	3.6	-31.6	>7.6	<-35.6	>7.6	<-35.6	>7.6	<-35.6	2.6	-30.6
Strong	N+15	0.1	-28.1	>7.6	<-35.6	>7.6	<-35.6	>7.6	<-35.6	2.1	-30.1

Table 2 – Unfiltered DTV Interference into Strong DTV

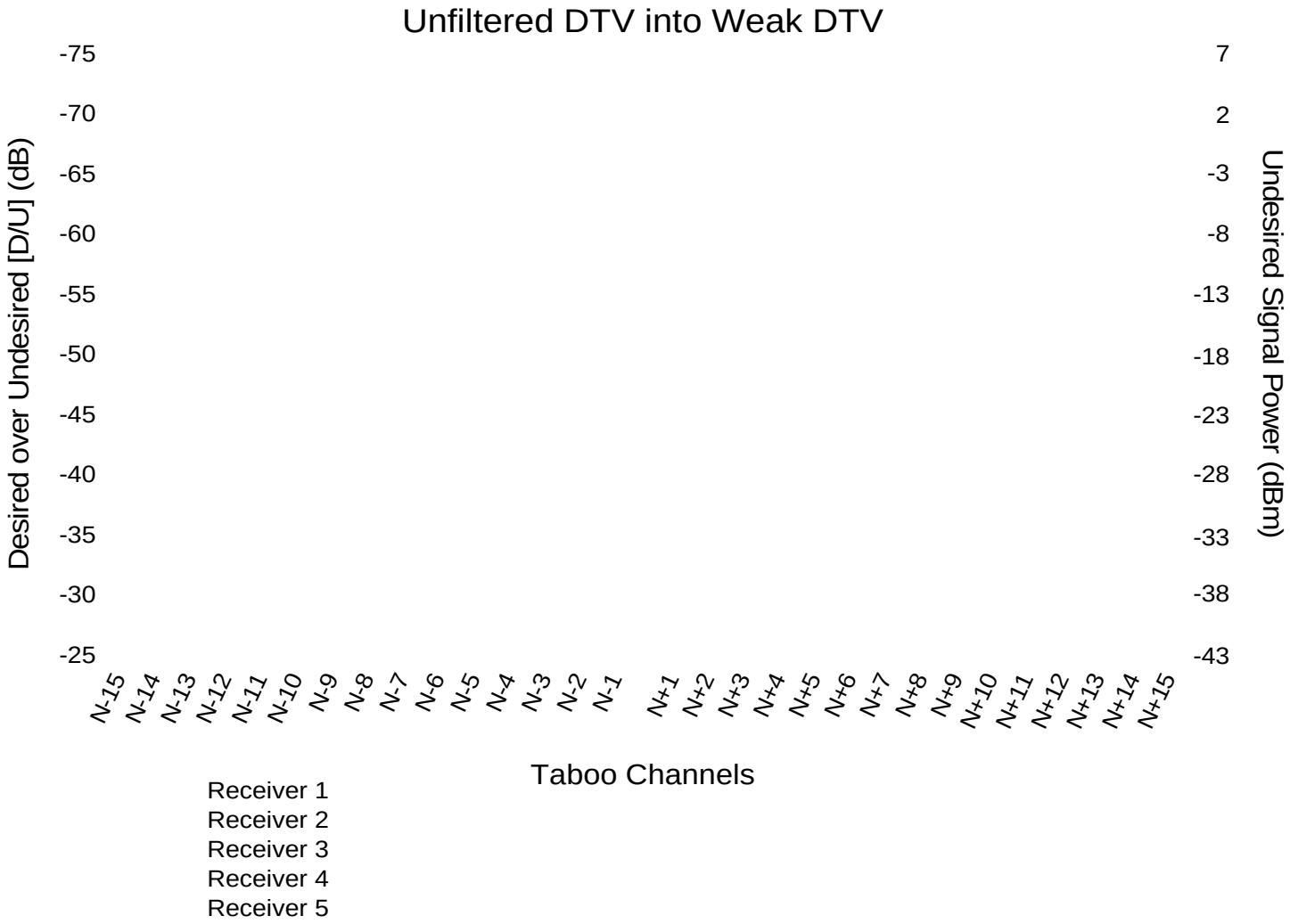
Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Moderate	N-15	0.8	-53.8	>5.8	<-58.8	-5.7	-47.3	-0.7	-52.3	0.3	-53.3
Moderate	N-14	-15.2	-37.8	>5.8	<-58.8	-6.7	-46.3	-2.2	-50.8	-0.2	-52.8
Moderate	N-13	1.3	-54.3	>5.8	<-58.8	-7.7	-45.3	-4.2	-48.8	0.3	-53.3
Moderate	N-12	1.4	-54.4	>5.9	<-58.9	-9.6	-43.4	-6.1	-46.9	0.4	-53.4
Moderate	N-11	-0.6	-52.4	>5.9	<-58.9	-11.1	-41.9	-8.6	-44.4	0.4	-53.4
Moderate	N-10	1.8	-54.8	>5.8	<-58.8	-12.2	-40.8	-9.7	-43.3	-0.2	-52.8
Moderate	N-9	1.8	-54.8	5.3	-58.3	-13.7	-39.3	-12.2	-40.8	-1.7	-51.3
Moderate	N-8	1.6	-54.6	5.1	-58.1	-15.4	-37.6	-13.9	-39.1	-2.9	-50.1
Moderate	N-7	-1.4	-51.6	>5.6	<-58.6	-16.9	-36.1	-15.9	-37.1	-4.4	-48.6
Moderate	N-6	1.7	-54.7	>5.7	<-58.7	-17.3	-35.7	-17.3	-35.7	0.7	-53.7
Moderate	N-5	-2.5	-50.5	>5.5	<-58.5	1.0	-54.0	-18.5	-34.5	1.5	-54.5
Moderate	N-4	-8.3	-44.7	>5.7	<-58.7	-17.8	-35.2	-1.8	-51.2	0.7	-53.7
Moderate	N-3	-12.4	-40.6	-0.9	-52.1	-18.9	-34.1	-1.4	-51.6	-2.4	-50.6
Moderate	N-2	-13.8	-39.2	-9.8	-43.2	-8.3	-44.7	-8.3	-44.7	-10.3	-42.7
Moderate	N-1	-23.3	-29.7	-16.8	-36.2	-16.3	-36.7	-15.8	-37.2	-15.3	-37.7
Moderate	N+1	-26.0	-27.0	-15.0	-38.0	-16.5	-36.5	-14.0	-39.0	-15.0	-38.0
Moderate	N+2	-16.3	-36.7	-7.3	-45.7	-7.3	-45.7	-6.3	-46.7	-7.8	-45.2
Moderate	N+3	-8.3	-44.7	2.2	-55.2	-23.3	-29.7	-9.8	-43.2	-0.8	-52.2
Moderate	N+4	-7.7	-45.3	5.8	-58.8	-20.2	-32.8	-5.7	-47.3	0.8	-53.8
Moderate	N+5	1.4	-54.4	-1.6	-51.4	-19.6	-33.4	-5.1	-47.9	0.9	-53.9
Moderate	N+6	3.4	-56.4	2.9	-55.9	-10.6	-42.4	1.9	-54.9	-0.6	-52.4
Moderate	N+7	-17.6	-35.4	2.4	-55.4	-21.6	-31.4	-1.1	-51.9	-6.6	-46.4
Moderate	N+8	5.5	-58.5	6.0	-59.0	-0.5	-52.5	6.5	-59.5	-1.0	-52.0
Moderate	N+9	5.5	-58.5	>7	<-60	3.5	-56.5	>7.0	<-60.0	-0.5	-52.5
Moderate	N+10	0.2	-53.2	6.7	-59.7	5.7	-58.7	6.7	-59.7	-0.3	-52.7
Moderate	N+11	4.6	-57.6	>7.1	<-60.1	>7.1	<-60.1	>7.1	<-60.1	0.1	-53.1
Moderate	N+12	3.6	-56.6	>7.1	<-60.1	>7.1	<-60.1	>7.1	<-60.1	-0.4	-52.6
Moderate	N+13	1.8	-54.8	>7.3	<-60.3	>7.3	<-60.3	>7.3	<-60.3	-0.2	-52.8
Moderate	N+14	-17.9	-35.1	7.1	-60.1	-15.4	-37.6	-4.9	-48.1	-0.4	-52.6
Moderate	N+15	-21.4	-31.6	5.6	-58.6	-17.4	-35.6	-5.9	-47.1	-0.9	-52.1

Table 3 – Unfiltered DTV Interference into Moderate DTV



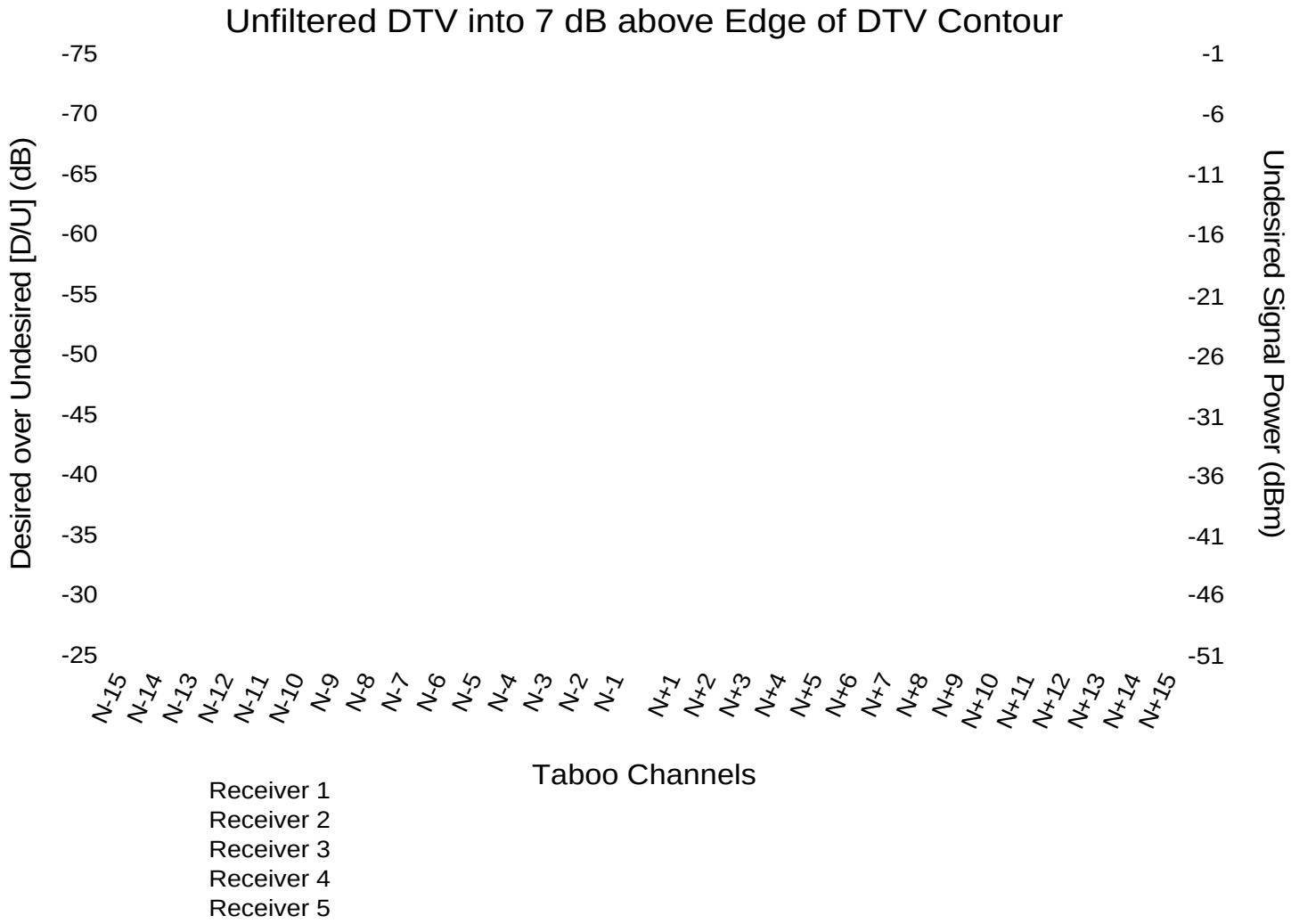
Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Weak	N-15	-13.2	-54.8	5.3	-73.3	-7.2	-60.8	-3.7	-64.3	-0.2	-67.8
Weak	N-14	-30.2	-37.8	3.8	-71.8	-6.7	-61.3	-3.2	-64.8	-0.2	-67.8
Weak	N-13	-12.7	-55.3	4.8	-72.8	-8.2	-59.8	-5.2	-62.8	-0.2	-67.8
Weak	N-12	-12.1	-55.9	-0.6	-67.4	-10.6	-57.4	-8.1	-59.9	-4.1	-63.9
Weak	N-11	-14.6	-53.4	-1.6	-66.4	-13.6	-54.4	-11.6	-56.4	-2.6	-65.4
Weak	N-10	-11.7	-56.3	-1.7	-66.3	-12.7	-55.3	-10.7	-57.3	-2.7	-65.3
Weak	N-9	-11.7	-56.3	-3.2	-64.8	-17.2	-50.8	-16.2	-51.8	-4.7	-63.3
Weak	N-8	-12.4	-55.6	-1.4	-66.6	-15.9	-52.1	-14.4	-53.6	-5.4	-62.6
Weak	N-7	-15.9	-52.1	-6.9	-61.1	-16.9	-51.1	-16.9	-51.1	-8.4	-59.6
Weak	N-6	-11.8	-56.2	-2.3	-65.7	-17.8	-50.2	-17.8	-50.2	-5.8	-62.2
Weak	N-5	-16.0	-52.0	-3.0	-65.0	-19.5	-48.5	-19.5	-48.5	-6.0	-62.0
Weak	N-4	-22.3	-45.7	-8.8	-59.2	-19.8	-48.2	-18.3	-49.7	-10.3	-57.7
Weak	N-3	-26.4	-41.6	-16.9	-51.1	-21.9	-46.1	-16.9	-51.1	-17.4	-50.6
Weak	N-2	-27.8	-40.2	-26.8	-41.2	-23.8	-44.2	-23.8	-44.2	-24.8	-43.2
Weak	N-1	-38.3	-29.7	-33.8	-34.2	-31.3	-36.7	-30.8	-37.2	-30.3	-37.7
Weak	N+1	-40.5	-27.5	-31.0	-37.0	-31.5	-36.5	-29.0	-39.0	-31.0	-37.0
Weak	N+2	-30.8	-37.2	-22.8	-45.2	-22.3	-45.7	-21.3	-46.7	-23.8	-44.2
Weak	N+3	-22.8	-45.2	-13.3	-54.7	-24.8	-43.2	-13.3	-54.7	-14.3	-53.7
Weak	N+4	-22.2	-45.8	-7.2	-60.8	-21.7	-46.3	-10.7	-57.3	-9.2	-58.8
Weak	N+5	-12.6	-55.4	-11.6	-56.4	-24.1	-43.9	-10.1	-57.9	-7.6	-60.4
Weak	N+6	-10.1	-57.9	-2.6	-65.4	-13.6	-54.4	-2.1	-65.9	-4.1	-63.9
Weak	N+7	-31.6	-36.4	-2.6	-65.4	-21.6	-46.4	-5.1	-62.9	-8.1	-59.9
Weak	N+8	-8.5	-59.5	-1.5	-66.5	-2.5	-65.5	-1.5	-66.5	-3.0	-65.0
Weak	N+9	-8.0	-60.0	-2.0	-66.0	-1.0	-67.0	-1.0	-67.0	-3.0	-65.0
Weak	N+10	-14.3	-53.7	-0.8	-67.2	-1.3	-66.7	-0.3	-67.7	-2.8	-65.2
Weak	N+11	-9.9	-58.1	-1.4	-66.6	0.1	-68.1	-0.4	-67.6	-2.4	-65.6
Weak	N+12	-10.9	-57.1	-1.4	-66.6	0.1	-68.1	-0.9	-67.1	-2.4	-65.6
Weak	N+13	-11.7	-56.3	-1.7	-66.3	0.3	-68.3	-0.2	-67.8	-2.7	-65.3
Weak	N+14	-32.9	-35.1	-6.9	-61.1	-30.4	-37.6	-20.4	-47.6	-11.4	-56.6
Weak	N+15	-36.4	-31.6	-9.4	-58.6	-31.9	-36.1	-20.9	-47.1	-12.4	-55.6

Table 4 – Unfiltered DTV Interference into Weak DTV



Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Contour+7dB	N-15	-14.2	-61.8	-3.2	-72.8	-9.7	-66.3	-6.2	-69.8	-4.2	-71.8
Contour+7dB	N-14	-34.2	-41.8	-5.2	-70.8	-8.2	-67.8	-6.2	-69.8	-5.7	-70.3
Contour+7dB	N-13	-13.7	-62.3	-4.2	-71.8	-9.7	-66.3	-7.7	-68.3	-5.2	-70.8
Contour+7dB	N-12	-13.6	-62.4	-9.6	-66.4	-13.1	-62.9	-11.6	-64.4	-10.6	-65.4
Contour+7dB	N-11	-17.1	-58.9	-10.6	-65.4	-16.1	-59.9	-14.1	-61.9	-11.1	-64.9
Contour+7dB	N-10	-13.2	-62.8	-10.7	-65.3	-14.2	-61.8	-13.2	-62.8	-11.7	-64.3
Contour+7dB	N-9	-13.7	-62.3	-12.2	-63.8	-19.2	-56.8	-18.7	-57.3	-13.2	-62.8
Contour+7dB	N-8	-14.4	-61.6	-10.4	-65.6	-17.4	-58.6	-16.9	-59.1	-10.9	-65.1
Contour+7dB	N-7	-19.9	-56.1	-16.9	-59.1	-18.9	-57.1	-18.9	-57.1	-16.4	-59.6
Contour+7dB	N-6	-12.8	-63.2	-10.8	-65.2	-19.3	-56.7	-19.3	-56.7	-13.3	-62.7
Contour+7dB	N-5	-18.0	-58.0	-11.5	-64.5	-21.5	-54.5	-21.5	-54.5	-14.0	-62.0
Contour+7dB	N-4	-22.8	-53.2	-17.3	-58.7	-21.8	-54.2	-21.8	-54.2	-19.3	-56.7
Contour+7dB	N-3	-27.4	-48.6	-25.9	-50.1	-24.4	-51.6	-24.9	-51.1	-26.4	-49.6
Contour+7dB	N-2	-31.3	-44.7	-34.8	-41.2	-32.3	-43.7	-31.8	-44.2	-34.3	-41.7
Contour+7dB	N-1	-40.8	-35.2	-41.8	-34.2	-40.3	-35.7	-39.3	-36.7	-39.3	-36.7
Contour+7dB	N+1	-49.0	-27.0	-39.0	-37.0	-40.0	-36.0	-37.5	-38.5	-39.5	-36.5
Contour+7dB	N+2	-32.3	-43.7	-31.3	-44.7	-31.3	-44.7	-30.3	-45.7	-32.8	-43.2
Contour+7dB	N+3	-23.8	-52.2	-21.8	-54.2	-26.8	-49.2	-21.3	-54.7	-23.8	-52.2
Contour+7dB	N+4	-27.2	-48.8	-14.7	-61.3	-24.2	-51.8	-15.7	-60.3	-18.2	-57.8
Contour+7dB	N+5	-14.6	-61.4	-15.1	-60.9	-27.1	-48.9	-13.6	-62.4	-14.6	-61.4
Contour+7dB	N+6	-12.1	-63.9	-10.6	-65.4	-15.6	-60.4	-10.6	-65.4	-11.1	-64.9
Contour+7dB	N+7	-32.1	-43.9	-10.6	-65.4	-23.1	-52.9	-11.1	-64.9	-12.6	-63.4
Contour+7dB	N+8	-11.5	-64.5	-10.0	-66.0	-10.0	-66.0	-10.0	-66.0	-11.0	-65.0
Contour+7dB	N+9	-11.5	-64.5	-11.0	-65.0	-9.5	-66.5	-10.0	-66.0	-11.5	-64.5
Contour+7dB	N+10	-17.3	-58.7	-8.8	-67.2	-9.3	-66.7	-8.8	-67.2	-10.8	-65.2
Contour+7dB	N+11	-13.4	-62.6	-10.4	-65.6	-8.9	-67.1	-9.4	-66.6	-10.9	-65.1
Contour+7dB	N+12	-12.4	-63.6	-10.4	-65.6	-8.9	-67.1	-9.9	-66.1	-10.9	-65.1
Contour+7dB	N+13	-13.7	-62.3	-11.2	-64.8	-8.7	-67.3	-9.2	-66.8	-11.7	-64.3
Contour+7dB	N+14	-41.4	-34.6	-16.4	-59.6	-38.9	-37.1	-29.4	-46.6	-20.9	-55.1
Contour+7dB	N+15	-45.4	-30.6	-18.4	-57.6	-40.9	-35.1	-30.4	-45.6	-21.9	-54.1

Table 5 – Unfiltered DTV Interference into 7 dB above Edge of DTV Contour



Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
-15 dBm	N-15	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	1.2	-16.2
-15 dBm	N-14	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	1.2	-16.2
-15 dBm	N-13	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	1.1	-16.1
-15 dBm	N-12	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	1.7	-16.7
-15 dBm	N-11	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	1.6	-16.6
-15 dBm	N-10	>11.5	<-26.5	>11.5	<-26.5	>11.5	<-26.5	>11.5	<-26.5	1.5	-16.5
-15 dBm	N-9	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	1.1	-16.1
-15 dBm	N-8	>11.7	<-26.7	>11.7	<-26.7	11.2	-26.2	>11.7	<-26.7	0.7	-15.7
-15 dBm	N-7	>11.7	<-26.7	>11.7	<-26.7	11.2	-26.2	>11.7	<-26.7	0.7	-15.7
-15 dBm	N-6	>11.7	<-26.7	>11.7	<-26.7	9.7	-24.7	>11.7	<-26.7	0.7	-15.7
-15 dBm	N-5	>11.7	<-26.7	>11.7	<-26.7	8.7	-23.7	>11.7	<-26.7	0.2	-15.2
-15 dBm	N-4	>11.7	<-26.7	>11.7	<-26.7	7.7	-22.7	11.2	-26.2	0.2	-15.2
-15 dBm	N-3	>11.8	<-26.8	11.3	-26.3	6.3	-21.3	10.8	-25.8	-0.2	-14.8
-15 dBm	N-2	>11.6	<-26.6	>11.6	<-26.6	4.1	-19.1	8.6	-23.6	0.1	-15.1
-15 dBm	N-1	>11.8	<-26.8	9.3	-24.3	4.8	-19.8	1.8	-16.8	-2.2	-12.8
-15 dBm	N+1	>11.5	<-26.5	>11.5	<-26.5	5.0	-20.0	4.0	-19.0	-1.5	-13.5
-15 dBm	N+2	>11.6	<-26.6	>11.6	<-26.6	6.1	-21.1	>11.6	<-26.6	0.6	-15.6
-15 dBm	N+3	>11.6	<-26.6	>11.6	<-26.6	8.6	-23.6	>11.6	<-26.6	1.1	-16.1
-15 dBm	N+4	>11.6	<-26.6	>11.6	<-26.6	10.6	-25.6	>11.6	<-26.6	1.1	-16.1
-15 dBm	N+5	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	0.7	-15.7
-15 dBm	N+6	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	0.7	-15.7
-15 dBm	N+7	>11.6	<-26.6	>11.6	<-26.6	-2.9	-12.1	9.1	-24.1	0.6	-15.6
-15 dBm	N+8	>11.9	<-26.9	>11.9	<-26.9	>11.9	<-26.9	>11.9	<-26.9	0.9	-15.9
-15 dBm	N+9	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	0.7	-15.7
-15 dBm	N+10	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	1.1	-16.1
-15 dBm	N+11	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	1.7	-16.7
-15 dBm	N+12	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	>11.7	<-26.7	2.2	-17.2
-15 dBm	N+13	>11.8	<-26.8	>11.8	<-26.8	>11.8	<-26.8	>11.8	<-26.8	1.8	-16.8
-15 dBm	N+14	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	1.6	-16.6
-15 dBm	N+15	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	>11.6	<-26.6	1.1	-16.1

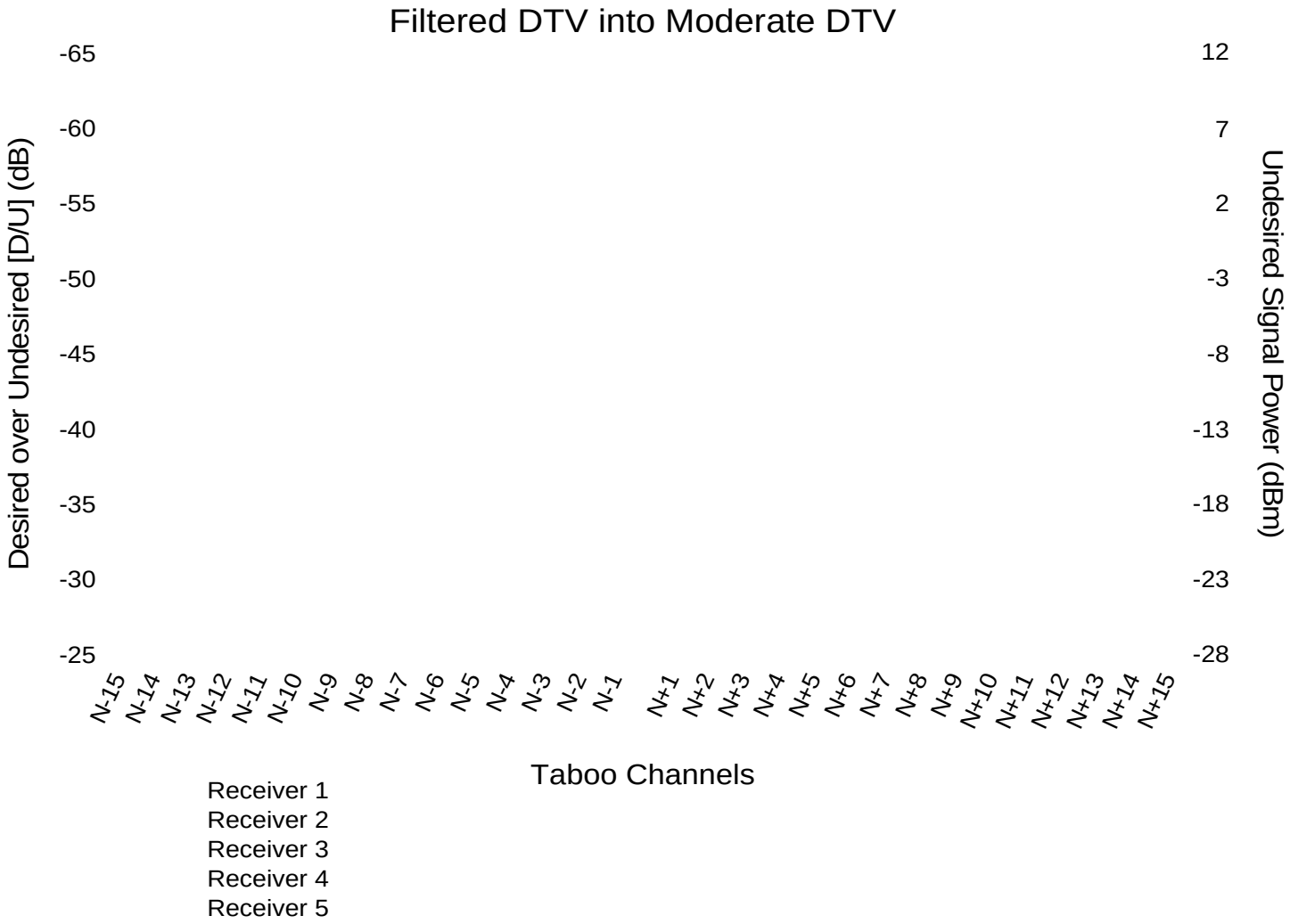
Table 6 – Filtered DTV Interference into Very Strong DTV (-15 dBm)

Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Strong	N-15	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	1.2	-29.2
Strong	N-14	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	1.2	-29.2
Strong	N-13	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	1.1	-29.1
Strong	N-12	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	1.7	-29.7
Strong	N-11	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	10.6	-38.6	1.6	-29.6
Strong	N-10	>11.5	<-39.5	>11.5	<-39.5	>11.5	<-39.5	8.0	-36.0	1.0	-29.0
Strong	N-9	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	5.1	-33.1	0.6	-28.6
Strong	N-8	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	2.7	-30.7	0.7	-28.7
Strong	N-7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	1.7	-29.7	0.7	-28.7
Strong	N-6	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	0.7	-28.7	0.2	-28.2
Strong	N-5	>11.7	<-39.7	>11.7	<-39.7	11.2	-39.2	1.7	-29.7	0.7	-28.7
Strong	N-4	>11.7	<-39.7	>11.7	<-39.7	9.2	-37.2	11.2	-39.2	-0.8	-27.2
Strong	N-3	>11.8	<-39.8	11.3	-39.3	6.3	-34.3	10.8	-38.8	-0.2	-27.8
Strong	N-2	>11.6	<-39.6	>11.6	<-39.6	4.1	-32.1	8.1	-36.1	-0.9	-27.1
Strong	N-1	2.8	-30.8	-0.7	-27.3	-3.2	-24.8	-0.7	-27.3	-5.2	-22.8
Strong	N+1	-1.5	-26.5	1.5	-29.5	-4.0	-24.0	1.0	-29.0	-5.0	-23.0
Strong	N+2	8.1	-36.1	>11.6	<-39.6	6.1	-34.1	>11.6	<-39.6	0.1	-28.1
Strong	N+3	>11.6	<-39.6	>11.6	<-39.6	9.1	-37.1	7.1	-35.1	1.1	-29.1
Strong	N+4	>11.6	<-39.6	>11.6	<-39.6	7.1	-35.1	11.1	-39.1	2.1	-30.1
Strong	N+5	>11.7	<-39.7	>11.7	<-39.7	6.2	-34.2	11.2	-39.2	1.7	-29.7
Strong	N+6	>11.7	<-39.7	>11.7	<-39.7	10.2	-38.2	>11.7	<-39.7	2.7	-30.7
Strong	N+7	4.6	-32.6	>11.6	<-39.6	-3.9	-24.1	9.6	-37.6	1.6	-29.6
Strong	N+8	>11.9	<-39.9	>11.9	<-39.9	11.4	-39.4	>11.9	<-39.9	1.9	-29.9
Strong	N+9	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	1.2	-29.2
Strong	N+10	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	1.6	-29.6
Strong	N+11	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	2.2	-30.2
Strong	N+12	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	>11.7	<-39.7	3.2	-31.2
Strong	N+13	>11.8	<-39.8	>11.8	<-39.8	>11.8	<-39.8	>11.8	<-39.8	2.8	-30.8
Strong	N+14	4.1	-32.1	>11.6	<-39.6	>11.6	<-39.6	>11.6	<-39.6	2.1	-30.1
Strong	N+15	0.6	-28.6	>11.6	<-39.6	9.6	-37.6	>11.6	<-39.6	1.1	-29.1

Table 7 – Filtered DTV Interference into Strong DTV

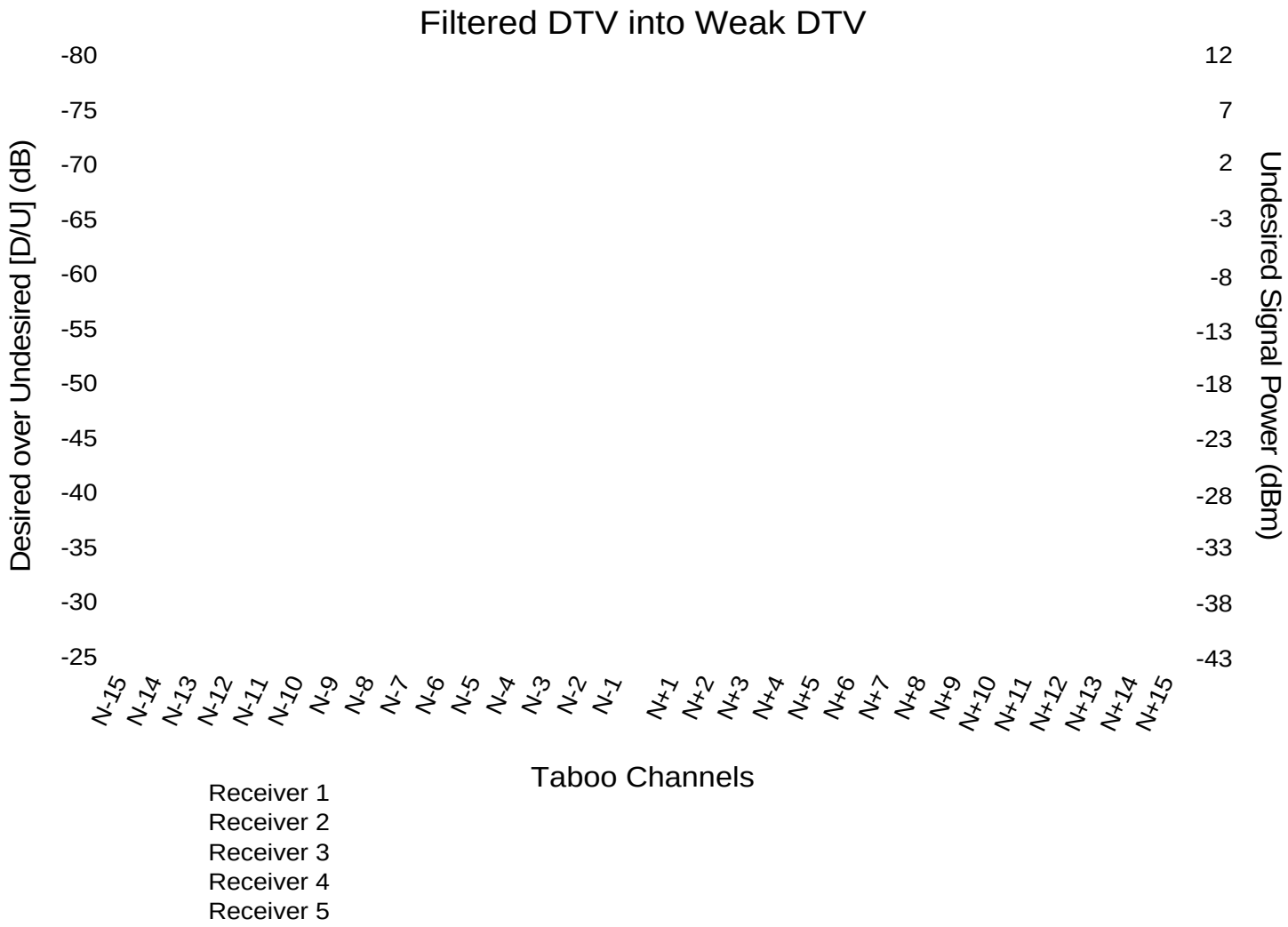
Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Moderate	N-15	5.7	-58.7	>11.7	<-64.7	-3.8	-49.2	10.2	-63.2	0.7	-53.7
Moderate	N-14	5.2	-58.2	>11.7	<-64.7	-5.8	-47.2	5.7	-58.7	0.2	-53.2
Moderate	N-13	5.1	-58.1	>11.6	<-64.6	-8.4	-44.6	1.6	-54.6	0.1	-53.1
Moderate	N-12	4.7	-57.7	11.2	-64.2	-9.8	-43.2	0.2	-53.2	-0.3	-52.7
Moderate	N-11	4.1	-57.1	10.1	-63.1	-11.9	-41.1	-2.4	-50.6	-0.9	-52.1
Moderate	N-10	4.0	-57.0	8.0	-61.0	-13.5	-39.5	-5.5	-47.5	-1.0	-52.0
Moderate	N-9	3.1	-56.1	6.6	-59.6	-15.4	-37.6	-7.4	-45.6	-1.9	-51.1
Moderate	N-8	2.7	-55.7	9.2	-62.2	-15.8	-37.2	-9.8	-43.2	-3.3	-49.7
Moderate	N-7	3.2	-56.2	>11.7	<-64.7	-16.8	-36.2	-12.3	-40.7	-3.8	-49.2
Moderate	N-6	3.2	-56.2	11.2	-64.2	5.2	-58.2	-13.3	-39.7	-0.3	-52.7
Moderate	N-5	0.2	-53.2	10.7	-63.7	5.7	-58.7	-14.8	-38.2	-0.8	-52.2
Moderate	N-4	-7.3	-45.7	4.7	-57.7	1.7	-54.7	1.2	-54.2	-1.3	-51.7
Moderate	N-3	-11.2	-41.8	-4.2	-48.8	-7.2	-45.8	4.8	-57.8	-3.2	-49.8
Moderate	N-2	-12.4	-40.6	-12.4	-40.6	-1.4	-51.6	-0.4	-52.6	-10.9	-42.1
Moderate	N-1	-22.7	-30.3	-19.2	-33.8	-15.2	-37.8	-12.7	-40.3	-13.7	-39.3
Moderate	N+1	-26.5	-26.5	-15.0	-38.0	-15.0	-38.0	-12.0	-41.0	-13.5	-39.5
Moderate	N+2	-15.9	-37.1	-3.4	-49.6	0.1	-53.1	9.1	-62.1	-4.4	-48.6
Moderate	N+3	-7.9	-45.1	9.1	-62.1	-22.4	-30.6	-7.4	-45.6	-1.9	-51.1
Moderate	N+4	-8.9	-44.1	>11.6	<-64.6	-20.4	-32.6	-3.4	-49.6	-0.4	-52.6
Moderate	N+5	0.2	-53.2	2.7	-55.7	-19.8	-33.2	-3.8	-49.2	-0.8	-52.2
Moderate	N+6	1.7	-54.7	4.7	-57.7	-10.8	-42.2	3.7	-56.7	-1.8	-51.2
Moderate	N+7	-18.4	-34.6	5.1	-58.1	-23.9	-29.1	-0.4	-52.6	-9.9	-43.1
Moderate	N+8	0.4	-53.4	8.4	-61.4	-0.1	-52.9	7.9	-60.9	-1.6	-51.4
Moderate	N+9	0.7	-53.7	9.7	-62.7	3.2	-56.2	8.7	-61.7	-1.3	-51.7
Moderate	N+10	0.6	-53.6	8.6	-61.6	4.1	-57.1	8.1	-61.1	-1.4	-51.6
Moderate	N+11	0.2	-53.2	>11.7	<-64.7	10.7	-63.7	10.7	-63.7	-0.8	-52.2
Moderate	N+12	0.2	-53.2	>11.7	<-64.7	>11.7	<-64.7	11.2	-64.2	-0.3	-52.7
Moderate	N+13	0.8	-53.8	>11.8	<-64.8	>11.8	<-64.8	>11.8	<-64.8	-0.2	-52.8
Moderate	N+14	-17.9	-35.1	8.6	-61.6	-15.4	-37.6	-4.9	-48.1	-0.9	-52.1
Moderate	N+15	-21.4	-31.6	7.1	-60.1	-18.9	-34.1	-6.4	-46.6	-1.4	-51.6

Table 8 – Filtered DTV Interference into Moderate DTV



Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Weak	N-15	-11.3	-56.7	>11.7	<-79.7	-4.3	-63.7	7.7	-75.7	0.2	-68.2
Weak	N-14	-11.3	-56.7	>11.7	<-79.7	-9.3	-58.7	1.7	-69.7	0.2	-68.2
Weak	N-13	-11.4	-56.6	>11.6	<-79.6	-13.9	-54.1	-2.9	-65.1	-0.4	-67.6
Weak	N-12	-11.8	-56.2	11.2	-79.2	-11.8	-56.2	-1.3	-66.7	-0.3	-67.7
Weak	N-11	-12.4	-55.6	9.1	-77.1	-12.4	-55.6	-3.4	-64.6	-0.9	-67.1
Weak	N-10	-13.0	-55.0	7.5	-75.5	-14.5	-53.5	-8.0	-60.0	-2.0	-66.0
Weak	N-9	-12.9	-55.1	5.6	-73.6	-15.9	-52.1	-8.9	-59.1	-3.4	-64.6
Weak	N-8	-12.8	-55.2	5.7	-73.7	-17.3	-50.7	-11.3	-56.7	-5.8	-62.2
Weak	N-7	-12.3	-55.7	8.7	-76.7	-18.8	-49.2	-13.3	-54.7	-8.8	-59.2
Weak	N-6	-12.3	-55.7	2.2	-70.2	-19.3	-48.7	-14.3	-53.7	-1.8	-66.2
Weak	N-5	-15.3	-52.7	-4.8	-63.2	-7.3	-60.7	-15.8	-52.2	-2.3	-65.7
Weak	N-4	-22.3	-45.7	-12.8	-55.2	-19.8	-48.2	-15.3	-52.7	-8.8	-59.2
Weak	N-3	-26.7	-41.3	-21.2	-46.8	-22.7	-45.3	-11.2	-56.8	-16.7	-51.3
Weak	N-2	-27.4	-40.6	-28.9	-39.1	-17.4	-50.6	-16.9	-51.1	-23.9	-44.1
Weak	N-1	-37.7	-30.3	-35.2	-32.8	-31.2	-36.8	-28.2	-39.8	-29.2	-38.8
Weak	N+1	-40.5	-27.5	-30.0	-38.0	-30.5	-37.5	-27.5	-40.5	-31.0	-37.0
Weak	N+2	-30.9	-37.1	-18.4	-49.6	-15.4	-52.6	-6.4	-61.6	-19.4	-48.6
Weak	N+3	-22.4	-45.6	-5.9	-62.1	-21.9	-46.1	-8.4	-59.6	-7.9	-60.1
Weak	N+4	-23.4	-44.6	-1.4	-66.6	-21.4	-46.6	-10.9	-57.1	-7.9	-60.1
Weak	N+5	-13.3	-54.7	-6.8	-61.2	-24.3	-43.7	-8.8	-59.2	-8.8	-59.2
Weak	N+6	-12.3	-55.7	2.2	-70.2	-13.8	-54.2	1.2	-69.2	-3.8	-64.2
Weak	N+7	-32.9	-35.1	3.6	-71.6	-22.4	-45.6	-1.4	-66.6	-10.4	-57.6
Weak	N+8	-14.1	-53.9	6.4	-74.4	-0.6	-67.4	7.9	-75.9	-1.6	-66.4
Weak	N+9	-13.3	-54.7	6.7	-74.7	0.2	-68.2	7.2	-75.2	-1.3	-66.7
Weak	N+10	-13.4	-54.6	2.1	-70.1	-1.4	-66.6	4.1	-72.1	-3.4	-64.6
Weak	N+11	-13.8	-54.2	9.7	-77.7	3.7	-71.7	9.2	-77.2	-0.8	-67.2
Weak	N+12	-13.3	-54.7	11.2	-79.2	>11.7	<-79.7	11.2	-79.2	-0.3	-67.7
Weak	N+13	-13.2	-54.8	>11.8	<-79.8	>11.8	<-79.8	11.3	-79.3	0.3	-68.3
Weak	N+14	-32.4	-35.6	-6.4	-61.6	-29.9	-38.1	-20.4	-47.6	-10.9	-57.1
Weak	N+15	-36.4	-31.6	-8.4	-59.6	-32.9	-35.1	-21.4	-46.6	-12.4	-55.6

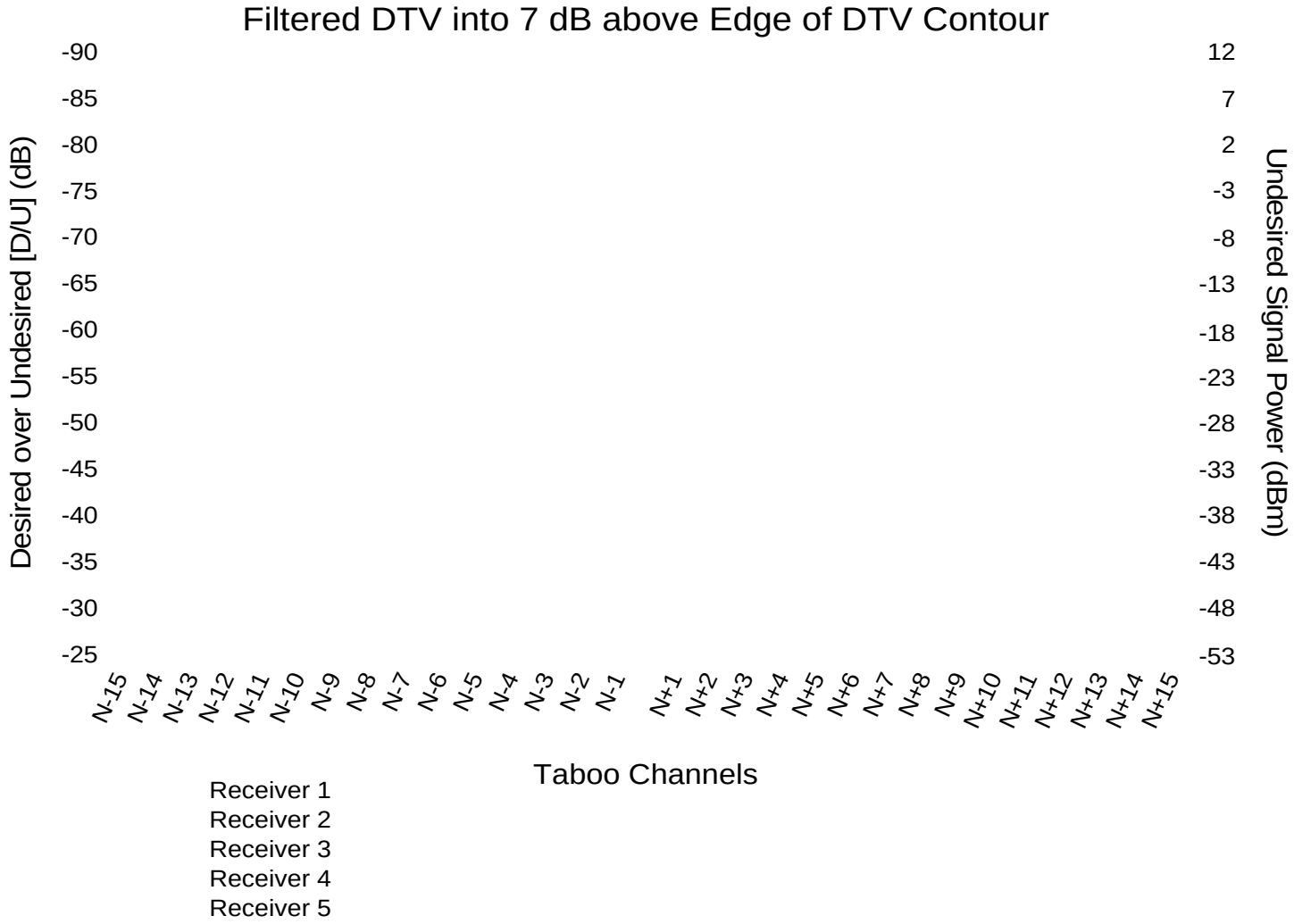
Table 9 – Filtered DTV Interference into Weak DTV



Desired Signal Level	Undesired DTV Channel	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
		Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)	Und. Level (dBm)	D/U (dB)
Contour+7dB	N-15	-13.3	-62.7	Fail	Fail	-6.3	-69.7	3.2	-79.2	-0.3	-75.7
Contour+7dB	N-14	-13.8	-62.2	Fail	Fail	-12.3	-63.7	-0.8	-75.2	-0.3	-75.7
Contour+7dB	N-13	-14.4	-61.6	Fail	Fail	-16.9	-59.1	-5.4	-70.6	-1.4	-74.6
Contour+7dB	N-12	-14.8	-61.2	8.7	-84.7	-13.3	-62.7	-4.3	-71.7	-0.8	-75.2
Contour+7dB	N-11	-14.9	-61.1	2.6	-78.6	-14.4	-61.6	-5.9	-70.1	-1.4	-74.6
Contour+7dB	N-10	-15.0	-61.0	6.0	-82.0	-17.5	-58.5	-11.0	-65.0	-2.5	-73.5
Contour+7dB	N-9	-14.9	-61.1	4.6	-80.6	-17.9	-58.1	-11.4	-64.6	-3.9	-72.1
Contour+7dB	N-8	-14.8	-61.2	3.2	-79.2	-19.3	-56.7	-13.8	-62.2	-6.3	-69.7
Contour+7dB	N-7	-14.3	-61.7	0.7	-76.7	-21.3	-54.7	-15.8	-60.2	-9.3	-66.7
Contour+7dB	N-6	-13.8	-62.2	-6.3	-69.7	-21.8	-54.2	-17.3	-58.7	-10.8	-65.2
Contour+7dB	N-5	-17.8	-58.2	-13.3	-62.7	-20.8	-55.2	-17.3	-58.7	-10.8	-65.2
Contour+7dB	N-4	-23.8	-52.2	-20.8	-55.2	-22.8	-53.2	-19.3	-56.7	-17.8	-58.2
Contour+7dB	N-3	-28.2	-47.8	-29.2	-46.8	-24.2	-51.8	-19.7	-56.3	-26.2	-49.8
Contour+7dB	N-2	-28.4	-47.6	-37.4	-38.6	-26.4	-49.6	-24.9	-51.1	-32.4	-43.6
Contour+7dB	N-1	-40.2	-35.8	-43.7	-32.3	-39.2	-36.8	-35.7	-40.3	-37.2	-38.8
Contour+7dB	N+1	-48.0	-28.0	-39.0	-37.0	-39.0	-37.0	-36.0	-40.0	-38.0	-38.0
Contour+7d	N+2	-31.4	-44.6	-26.9	-49.1	-23.9	-52.1	-14.9	-61.1	-28.4	-47.6

B											
Contour+7dB	N+3	-22.9	-53.1	-14.4	-61.6	-24.4	-51.6	-10.4	-65.6	-17.9	-58.1
Contour+7dB	N+4	-27.9	-48.1	-9.9	-66.1	-23.9	-52.1	-14.9	-61.1	-15.9	-60.1
Contour+7dB	N+5	-14.8	-61.2	-9.8	-66.2	-27.3	-48.7	-11.3	-64.7	-12.8	-63.2
Contour+7dB	N+6	-12.8	-63.2	0.7	-76.7	-16.3	-59.7	-0.8	-75.2	-9.8	-66.2
Contour+7dB	N+7	-33.9	-42.1	2.6	-78.6	-24.4	-51.6	-3.9	-72.1	-11.4	-64.6
Contour+7dB	N+8	-14.1	-61.9	5.9	-81.9	-4.1	-71.9	7.4	-83.4	-2.1	-73.9
Contour+7dB	N+9	-13.8	-62.2	5.7	-81.7	-2.3	-73.7	5.7	-81.7	-2.3	-73.7
Contour+7dB	N+10	-13.9	-62.1	-0.4	-75.6	-4.4	-71.6	1.6	-77.6	-5.9	-70.1
Contour+7dB	N+11	-14.8	-61.2	6.7	-82.7	Fail	Fail	6.7	-82.7	-1.3	-74.7
Contour+7dB	N+12	-13.8	-62.2	10.7	-86.7	>11.7	<-87.7	10.7	-86.7	-0.8	-75.2
Contour+7dB	N+13	-13.7	-62.3	>11.8	<-87.8	6.8	-82.8	10.3	-86.3	-0.7	-75.3
Contour+7dB	N+14	-40.9	-35.1	-15.4	-60.6	-38.9	-37.1	-29.4	-46.6	-20.4	-55.6
Contour+7dB	N+15	-45.4	-30.6	-16.9	-59.1	-41.9	-34.1	-30.4	-45.6	-21.4	-54.6

Table 10 – Filtered DTV Interference into 7 dB above Edge of DTV Contour



4.2 Results for Multiple DTV into DTV

The purpose of this test was to determine the performance of the 8-VSB receivers under the case of multiple interfering signals. Due to laboratory limitations, only the case of two interfering signals was evaluated. However, tests were conducted using both adjacent channel and taboo DTV channel interference. In some cases, the combination of the two undesired channels was set to create intermodulation products.

The following procedure was used to test the receivers under multiple undesired signals:

1. Each undesired signal was re-tested alone; the level of interference (D/U) at TOV was recorded for each single undesired DTV signal.
2. Both undesired signals were combined with the desired signal and connected to the receiver under test. Please refer to figure 1 for laboratory set-up.
3. The signal level of one of the undesired DTV signals (Undesired #1) was reduced by 3 dB according to the result obtained in step 1.
4. The level of interference (D/U) at TOV for the other undesired DTV signal (Undesired #2) was recorded.

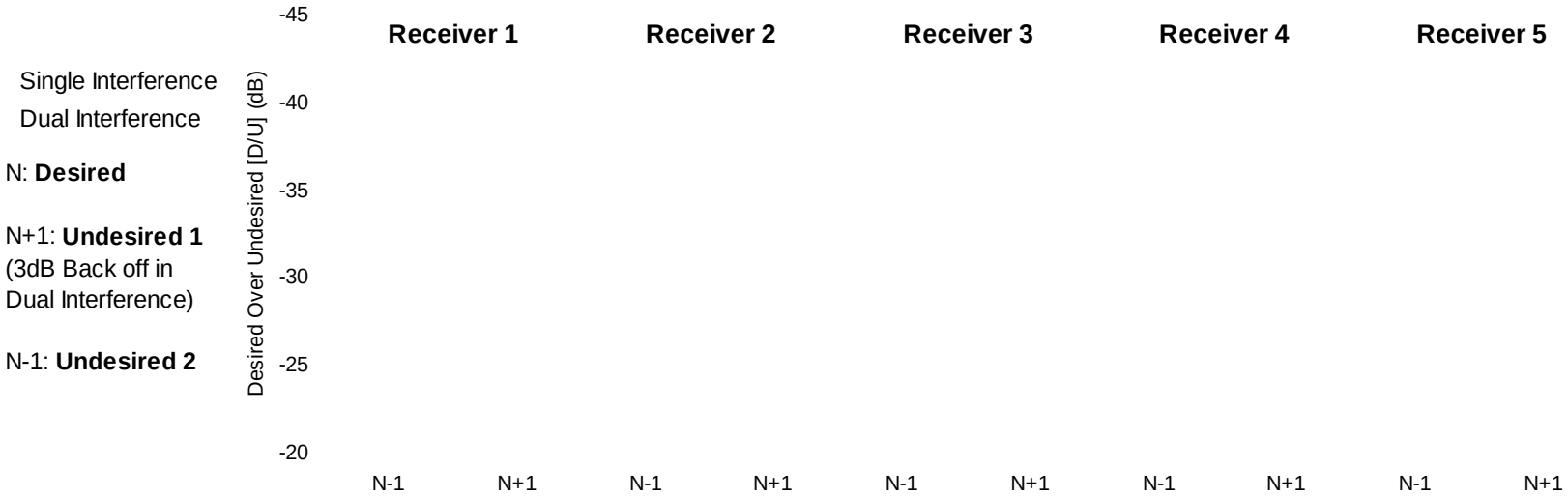
The tests were conducted only at ATSC Weak (-68dBm) power level for the desired DTV signal. The following scenarios were done:

- N-1 and N+1 into DTV;
- N-2 and N+2 into DTV;
- N-3 and N+3 into DTV;
- N-4 and N+3 into DTV;
- N+2 and N+3 into DTV;
- N+2 and N+4 into DTV;
- N+3 and N+6 into DTV;
- N+7 and N+14 into DTV.

As noted above, the Undesired #1 used in these testes was filtered according to the FCC DTV mask. Testing using two unfiltered signals was not done. In general, it would be expected that using two unfiltered signal could reduce the measured D/U ratios and therefore could increase the performance degradation shown.

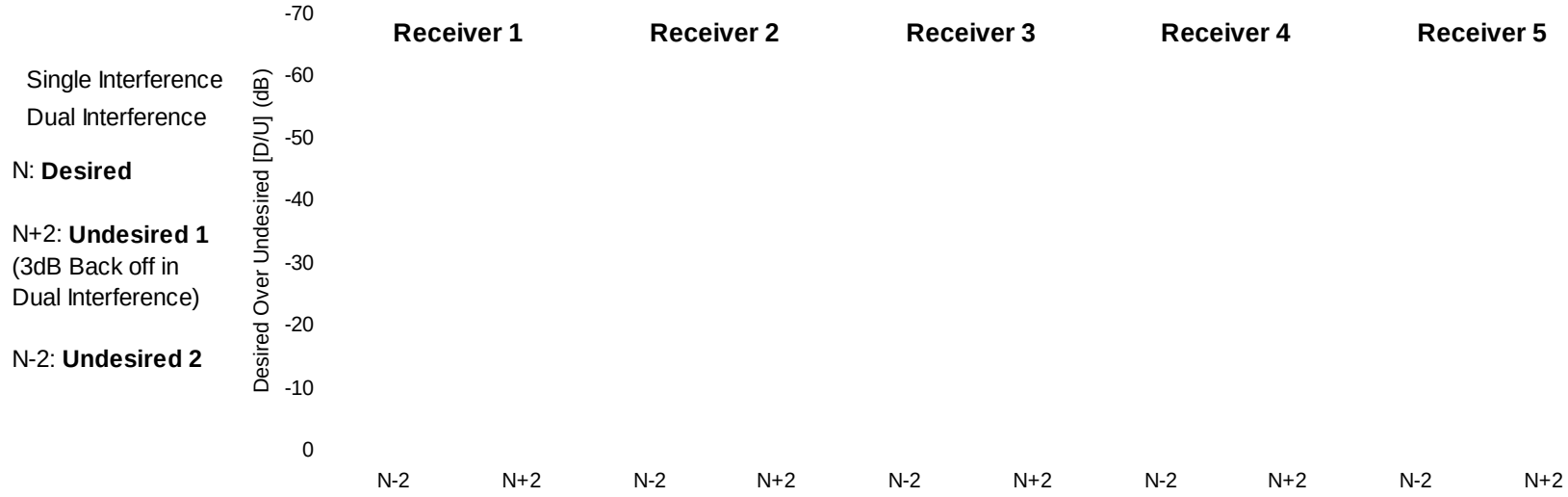
Test Condition Desired: -68 dBm Undesired #1 (U1): N+1 Undesired #2 (U2): N-1	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-40.5	-27.5	-30.0	-38.0	-30.5	-37.5	-27.5	-40.5	-28.5	-39.5
U2 at TOV only	-38.4	-29.6	-35.4	-32.6	-31.9	-36.1	-31.9	-36.1	-30.9	-37.1
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-32.4	-35.6	-38.9	-29.1	-33.9	-34.1	-34.4	-33.6	-35.4	-32.6
Degradation	**- 6.0 dB**		**3.5 dB**		**2.0 dB**		**2.5 dB**		**4.5 dB**	

Table 11 – N+1 and N-1 into Weak DTV



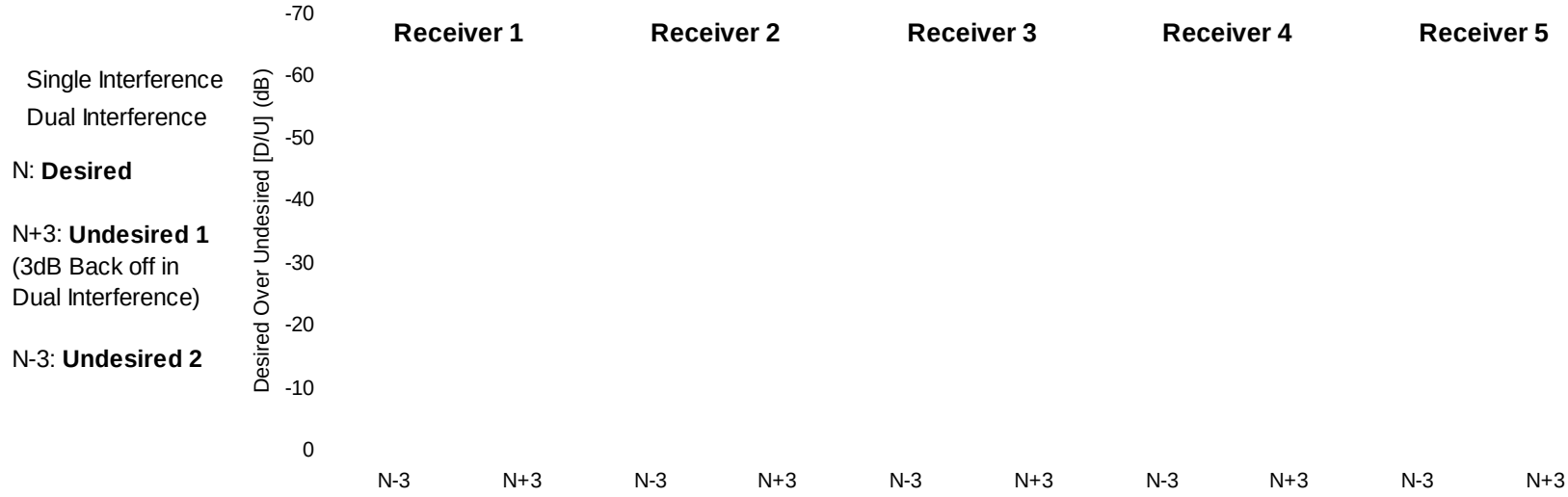
Test Condition Desired: -68 dBm Undesired #1 (U1): N+2 Undesired #2 (U2): N-2	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-30.2	-37.8	-17.7	-50.3	-15.2	-52.8	-6.7	-61.3	-18.7	-49.3
U2 at TOV only	-28.4	-39.6	-28.4	-39.6	-23.9	-44.1	-23.9	-44.1	-25.4	-42.6
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-28.9	-39.1	-34.4	-33.6	-26.4	-41.6	-26.9	-41.1	-28.4	-39.6
Degradation	**0.5 dB**		**6.0 dB**		**2.5 dB**		**3.0 dB**		**3.0 dB**	

Table 12 – N+2 and N-2 into Weak DTV



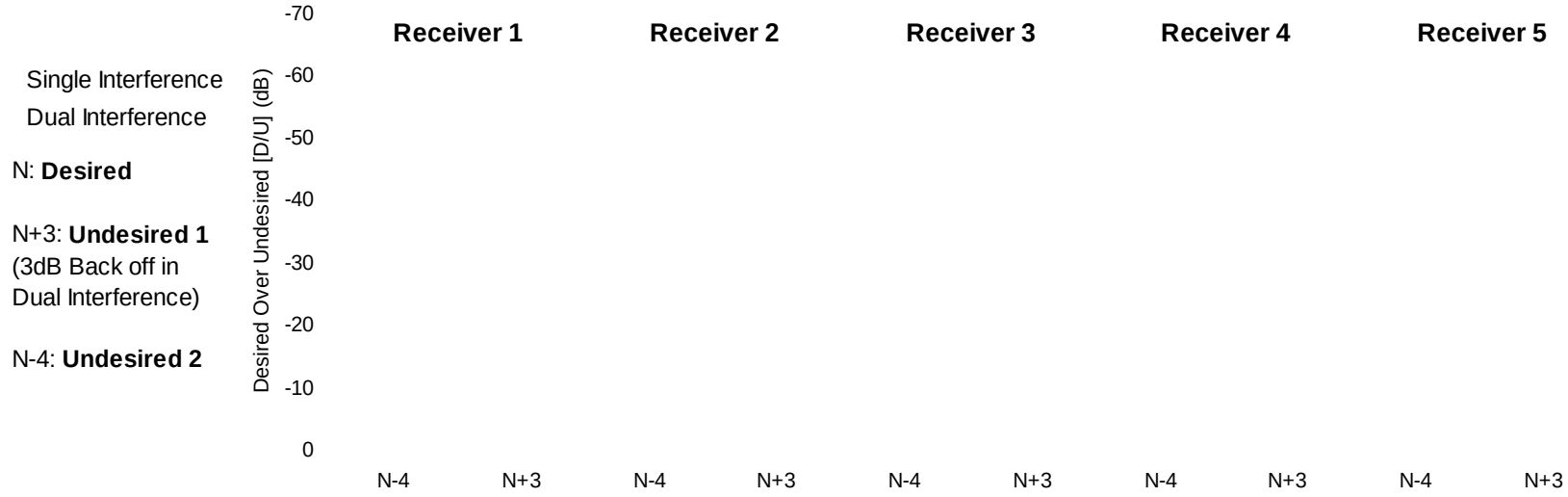
Test Condition Desired: -68 dBm Undesired #1 (U1): N+3 Undesired #2 (U2): N-3	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-21.7	-46.3	-6.2	-61.8	-24.2	-43.8	-8.7	-59.3	-7.7	-60.3
U2 at TOV only	-27.9	-40.1	-23.9	-44.1	-24.4	-43.6	-23.4	-44.6	-23.4	-44.6
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-29.4	-38.6	-26.4	-41.6	-41.4	-26.6	-39.4	-28.6	-26.9	-41.1
Degradation	**1.5 dB**		**2.5 dB**		**17.0 dB**		**16.0 dB**		**3.5 dB**	

Table 13 – N+3 and N-3 into Weak DTV



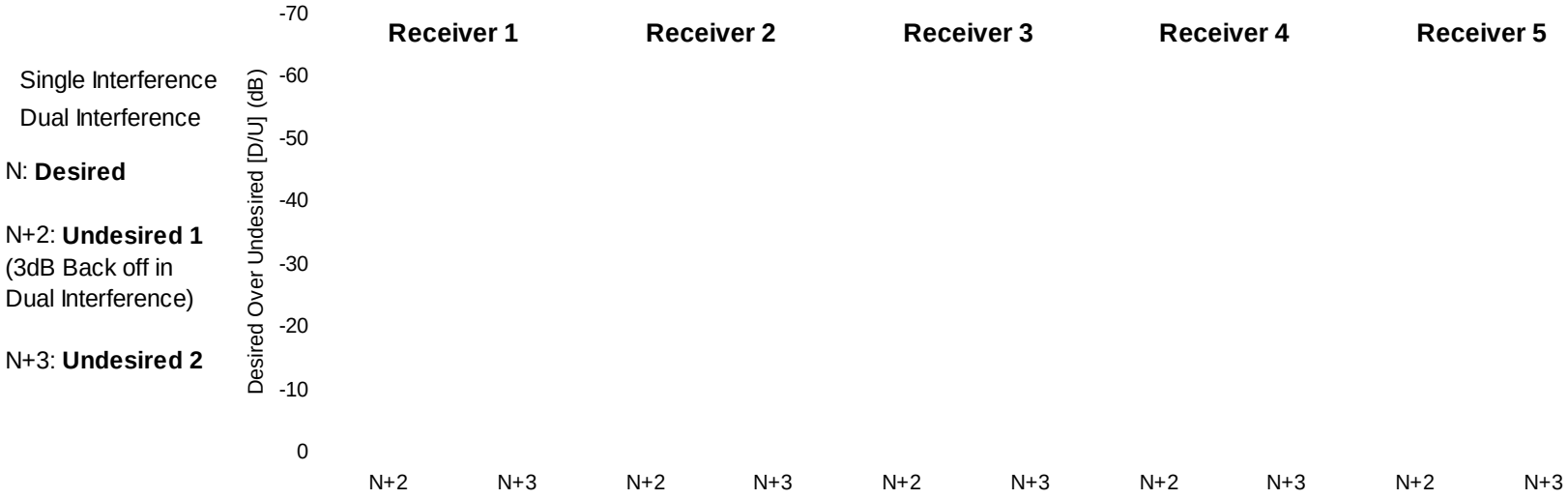
Test Condition Desired: -68 dBm Undesired #1 (U1): N+3 Undesired #2 (U2): N-4	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-22.1	-45.9	-5.6	-62.4	-24.6	-43.4	-8.6	-59.4	-7.6	-60.4
U2 at TOV only	-23.6	-44.4	-10.1	-57.9	-20.1	-47.9	-15.1	-52.9	-10.1	-57.9
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-48.1	-19.9	-14.6	-53.4	-36.1	-31.9	-36.6	-31.4	-21.6	-46.4
Degradation	**24.5 dB**		**4.5 dB**		**16.0 dB**		**21.5 dB**		**11.5 dB**	

Table 14 – N+3 and N-4 into Weak DTV



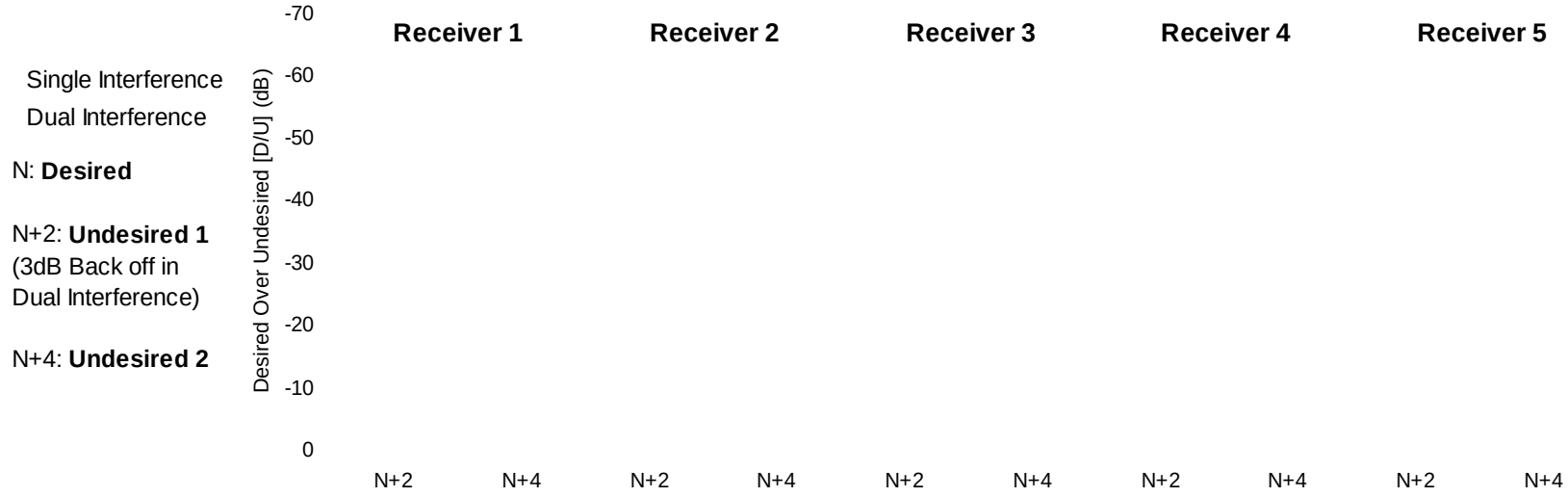
Test Condition Desired: -68 dBm Undesired #1 (U1): N+2 Undesired #2 (U2): N+3	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-30.5	-37.5	-18.5	-49.5	-15.0	-53.0	-6.0	-62.0	-18.5	-49.5
U2 at TOV only	-21.6	-46.4	-13.1	-54.9	-24.1	-43.9	-12.6	-55.4	-13.6	-54.4
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-27.6	-40.4	-15.6	-52.4	-27.6	-40.4	-25.1	-42.9	-16.6	-51.4
Degradation	**6.0 dB**		**2.5 dB**		**3.5 dB**		**12.5 dB**		**3.0 dB**	

Table 15 – N+2 and N+3 into Weak



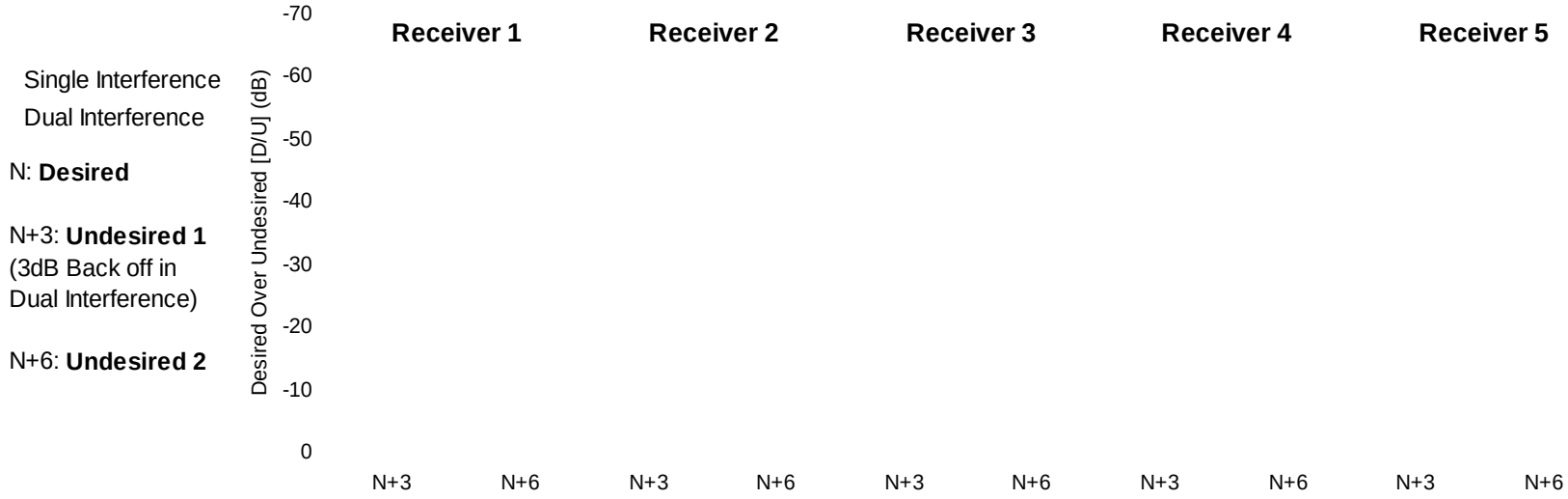
Test Condition Desired: -68 dBm Undesired #1 (U1): N+2 Undesired #2 (U2): N+4	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-30.5	-37.5	-18.5	-49.5	-15.0	-53.0	-6.5	-61.5	-19.0	-49.0
U2 at TOV only	-22.8	-45.2	-7.8	-60.2	-20.3	-47.7	-10.8	-57.2	-9.3	-58.7
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-31.3	-36.7	-9.3	-58.7	-31.8	-36.2	-33.3	-34.7	-17.3	-50.7
Degradation	**8.5 dB**		**1.5 dB**		**11.5 dB**		**22.5 dB**		**8.0 dB**	

Table 16 – N+2 and N+4 into Weak DTV



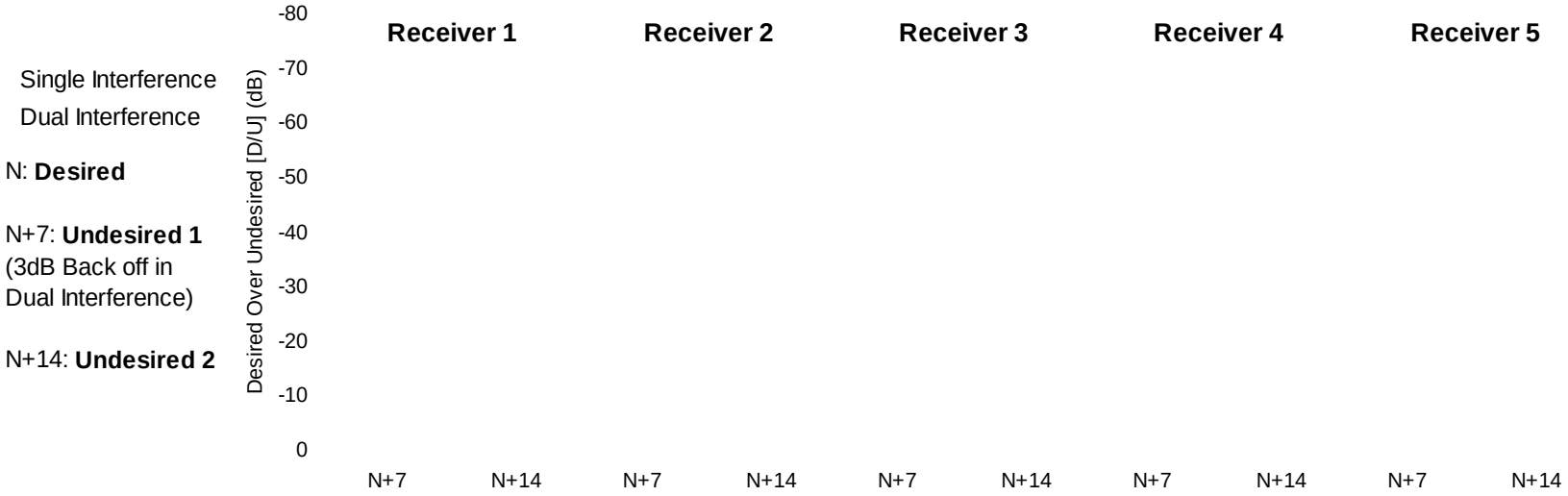
Test Condition Desired: -68 dBm Undesired #1 (U1): N+3 Undesired #2 (U2): N+6	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-22.0	-46.0	-6.0	-62.0	-24.5	-43.5	-8.5	-59.5	-8.0	-60.0
U2 at TOV only	-13.3	-54.7	-2.3	-65.7	-13.3	-54.7	-1.8	-66.2	-4.8	-63.2
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-42.8	-25.2	-22.3	-45.7	-44.8	-23.2	-35.8	-32.2	-37.8	-30.2
Degradation	**29.5 dB**		**20.0 dB**		**31.5 dB**		**34.0 dB**		**33.0 dB**	

Table 17 – N+3 and N+6 into Weak DTV



Test Condition Desired: -68 dBm Undesired #1 (U1): N+7 Undesired #2 (U2): N+14	Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)	Undesired Signal Level (dBm)	D/U (dB)
Single Undesired into DTV										
U1 at TOV only	-32.5	-35.5	3.5	-71.5	-19.5	-48.5	-1.5	-66.5	-10.0	-58.0
U2 at TOV only	-35.5	-32.5	-10.5	-57.5	-30.0	-38.0	-19.5	-48.5	-12.0	-56.0
Multiple Undesired into DTV										
U2 at TOV In presence of U1 – 3dB	-38.0	-30.0	-35.0	-33.0	-32.0	-36.0	-29.0	-39.0	-36.5	-31.5
Degradation	**2.5 dB**		**24.5 dB**		**2.0 dB**		**9.5 dB**		**24.5 dB**	

Table 18 – N+7 and N+14 into Weak DTV



4.3 Calculations for Interference Distance from a Single Radiating Device

In this section, the distance "**r**", at which a radiating device can cause a DTV receiver to reach the threshold of visibility (TOV) of artifacts on its screen, is calculated and presented. TOV is the starting point of inability of the receiver to resolve interference. At any distance closer than "**r**" to the radiator where the interference to the DTV channel is higher, complete reception failure could be expected. This is because of the "cliff effect" that characterizes digital signal reception.

All the test results and the corresponding calculations presented below represent the case of single undesired adjacent channel interference (in the range of N-15 to N+15) into the desired DTV channel. For performing the calculations, "DTV into DTV adjacent channel D/U ratios" (obtained by tests; Tables 4, 5, 9 and 10) are used.

Tables 19 to 22 show the "D/U ratios @ TOV for adjacent channel DTV interference into DTV" for different conditions, the corresponding dBm values of the undesired DTV channel that causes TOV for the desired channel (obtained by subtracting D/U @ TOV from the dBm value of the desired signal), and the calculated values of "**r**".

As mentioned earlier, five different receivers (Rx. #1 to Rx. #5) are used and two cases of "fixed desired" and "fixed undesired" DTV channel conditions are considered. For the case of fixed desired, the desired DTV channel is taken to be Ch-32 and the undesired DTV channel is changed from Ch-17 to Ch-47 and is **unfiltered**. For the case of fixed undesired, the undesired DTV channel is **filtered** and is taken to be Ch-46 and the desired DTV channel is changed from Ch-61 to Ch-31.

For each of the above two conditions (fixed desired and fixed undesired), the test results and the calculations are shown for the two cases of weak (-68 dBm) and 7 dB above Edge of DTV Contour (-76 dBm) desired DTV signal levels.

In summary, the following four tables (19 to 22) are for:

- Fixed desired, and an ATSC weak (–68 dBm) desired signal level (undesired signal not filtered)
- Fixed desired, and a desired signal level at 7 dB above Edge of Contour Value (–76 dBm) (undesired signal not filtered)
- Fixed undesired, and an ATSC weak (–68 dBm) desired signal level (undesired signal filtered)
- Fixed undesired, and a desired signal level at 7 dB above Edge of Contour Value (–76 dBm) (undesired signal filtered)

The radiating device is assumed to be a point radiator with 100-mW output power and 6-dBi transmitting antenna gain, which is equivalent to maximum radiated power of 400-mW (or 26 dBm). The DTV receiving antenna is assumed to have 0-dBi gain, to be matched with the load or transmission line to which it is connected, and to have the same polarization as the incident wave.

Appendix 2 represents all the relations and the procedures that have been used, and all the assumptions that have been made to carry out the calculations.

Undesired DTV Channel	Receiver 1			Receiver 2			Receiver 3			Receiver 4			Receiver 5		
	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)
N–15	-13.2	-54.8	**4.4**	5.3	-73.3	**0.5**	-7.2	-60.8	**2.2**	-3.7	-64.3	**1.5**	-0.2	-67.8	**1.0**
N–14	-30.2	-37.8	**31.1**	3.8	-71.8	**0.6**	-6.7	-61.3	**2.1**	-3.2	-64.8	**1.4**	-0.2	-67.8	**1.0**
N–13	-12.7	-55.3	**4.1**	4.8	-72.8	**0.5**	-8.2	-59.8	**2.4**	-5.2	-62.8	**1.7**	-0.2	-67.8	**1.0**
N–12	-12.1	-55.9	**3.8**	-0.6	-67.4	**1.0**	-10.6	-57.4	**3.2**	-8.1	-59.9	**2.4**	-4.1	-63.9	**1.5**
N–11	-14.6	-53.4	**5.0**	-1.6	-66.4	**1.1**	-13.6	-54.4	**4.4**	-11.6	-56.4	**3.5**	-2.6	-65.4	**1.2**
N–10	-11.7	-56.3	**3.5**	-1.7	-66.3	**1.1**	-12.7	-55.3	**4.0**	-10.7	-57.3	**3.1**	-2.7	-65.3	**1.2**
N–9	-11.7	-56.3	**3.5**	-3.2	-64.8	**1.3**	-17.2	-50.8	**6.6**	-16.2	-51.8	**5.8**	-4.7	-63.3	**1.6**
N–8	-12.4	-55.6	**3.7**	-1.4	-66.6	**1.1**	-15.9	-52.1	**5.6**	-14.4	-53.6	**4.7**	-5.4	-62.6	**1.7**
N–7	-15.9	-52.1	**5.5**	-6.9	-61.1	**2.0**	-16.9	-51.1	**6.2**	-16.9	-51.1	**6.2**	-8.4	-59.6	**2.3**
N–6	-11.8	-56.2	**3.4**	-2.3	-65.7	**1.1**	-17.8	-50.2	**6.8**	-17.8	-50.2	**6.8**	-5.8	-62.2	**1.7**
N–5	-16.0	-52.0	**5.5**	-3.0	-65.0	**1.2**	-19.5	-48.5	**8.2**	-19.5	-48.5	**8.2**	-6.0	-62.0	**1.7**
N–4	-22.3	-45.7	**11.2**	-8.8	-59.2	**2.4**	-19.8	-48.2	**8.4**	-18.3	-49.7	**7.0**	-10.3	-57.7	**2.8**
N–3	-26.4	-41.6	**17.7**	-16.9	-51.1	**5.9**	-21.9	-46.1	**10.5**	-16.9	-51.1	**5.9**	-17.4	-50.6	**6.3**
N–2	-27.8	-40.2	**20.6**	-26.8	-41.2	**18.3**	-23.8	-44.2	**13.0**	-23.8	-44.2	**13.0**	-24.8	-43.2	**14.6**
N–1	-38.3	-29.7	**68.2**	-33.8	-34.2	**40.6**	-31.3	-36.7	**30.5**	-30.8	-37.2	**28.8**	-30.3	-37.7	**27.2**
N+1	-40.5	-27.5	**86.1**	-31.0	-37.0	**28.8**	-31.5	-36.5	**30.5**	-29.0	-39.0	**22.9**	-31.0	-37.0	**28.8**
N+2	-30.8	-37.2	**27.9**	-22.8	-45.2	**11.1**	-22.3	-45.7	**10.5**	-21.3	-46.7	**9.3**	-23.8	-44.2	**12.5**
N+3	-22.8	-45.2	**11.0**	-13.3	-54.7	**3.7**	-24.8	-43.2	**13.8**	-13.3	-54.7	**3.7**	-14.3	-53.7	**4.1**
N+4	-22.2	-45.8	**10.2**	-7.2	-60.8	**1.8**	-21.7	-46.3	**9.6**	-10.7	-57.3	**2.7**	-9.2	-58.8	**2.3**
N+5	-12.6	-55.4	**3.3**	-11.6	-56.4	**3.0**	-24.1	-43.9	**12.5**	-10.1	-57.9	**2.5**	-7.6	-60.4	**1.9**
N+6	-10.1	-57.9	**2.5**	-2.6	-65.4	**1.0**	-13.6	-54.4	**3.7**	-2.1	-65.9	**1.0**	-4.1	-63.9	**1.2**
N+7	-31.6	-36.4	**29.1**	-2.6	-65.4	**1.0**	-21.6	-46.4	**9.2**	-5.1	-62.9	**1.4**	-8.1	-59.9	**1.9**
N+8	-8.5	-59.5	**2.0**	-1.5	-66.5	**0.9**	-2.5	-65.5	**1.0**	-1.5	-66.5	**0.9**	-3.0	-65.0	**1.1**
N+9	-8.0	-60.0	**1.9**	-2.0	-66.0	**0.9**	-1.0	-67.0	**0.8**	-1.0	-67.0	**0.8**	-3.0	-65.0	**1.1**
N+10	-14.3	-53.7	**3.9**	-0.8	-67.2	**0.8**	-1.3	-66.7	**0.9**	-0.3	-67.7	**0.8**	-2.8	-65.2	**1.0**
N+11	-9.9	-58.1	**2.3**	-1.4	-66.6	**0.9**	0.1	-68.1	**0.7**	-0.4	-67.6	**0.8**	-2.4	-65.6	**1.0**
N+12	-10.9	-57.1	**2.6**	-1.4	-66.6	**0.9**	0.1	-68.1	**0.7**	-0.9	-67.1	**0.8**	-2.4	-65.6	**1.0**
N+13	-11.7	-56.3	**2.8**	-1.7	-66.3	**0.9**	0.3	-68.3	**0.7**	-0.2	-67.8	**0.7**	-2.7	-65.3	**1.0**
N+14	-32.9	-35.1	**31.7**	-6.9	-61.1	**1.6**	-30.4	-37.6	**23.8**	-20.4	-47.6	**7.5**	-11.4	-56.6	**2.7**
N+15	-36.4	-31.6	**47.0**	-9.4	-58.6	**2.1**	-31.9	-36.1	**28.0**	-20.9	-47.1	**7.9**	-12.4	-55.6	**3.0**

Table 19 – Unfiltered DTV into Weak Fixed DTV on Channel 32

Undesired DTV Channel	Receiver 1			Receiver 2			Receiver 3			Receiver 4			Receiver 5		
	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)
N–15	-14.2	-61.8	**5.0**	-3.2	-72.8	**1.4**	-9.7	-66.3	**3.0**	-6.2	-69.8	**2.0**	-4.2	-71.8	**1.6**
N–14	-34.2	-41.8	**49.2**	-5.2	-70.8	**1.7**	-8.2	-67.8	**2.5**	-6.2	-69.8	**2.0**	-5.7	-70.3	**1.8**
N–13	-13.7	-62.3	**4.6**	-4.2	-71.8	**1.5**	-9.7	-66.3	**2.9**	-7.7	-68.3	**2.3**	-5.2	-70.8	**1.7**
N–12	-13.6	-62.4	**4.5**	-9.6	-66.4	**2.8**	-13.1	-62.9	**4.2**	-11.6	-64.4	**3.6**	-10.6	-65.4	**3.2**
N–11	-17.1	-58.9	**6.6**	-10.6	-65.4	**3.1**	-16.1	-59.9	**5.9**	-14.1	-61.9	**4.7**	-11.1	-64.9	**3.3**
N–10	-13.2	-62.8	**4.2**	-10.7	-65.3	**3.1**	-14.2	-61.8	**4.7**	-13.2	-62.8	**4.2**	-11.7	-64.3	**3.5**
N–9	-13.7	-62.3	**4.4**	-12.2	-63.8	**3.7**	-19.2	-56.8	**8.3**	-18.7	-57.3	**7.8**	-13.2	-62.8	**4.1**
N–8	-14.4	-61.6	**4.7**	-10.4	-65.6	**3.0**	-17.4	-58.6	**6.6**	-16.9	-59.1	**6.3**	-10.9	-65.1	**3.1**
N–7	-19.9	-56.1	**8.7**	-16.9	-59.1	**6.2**	-18.9	-57.1	**7.8**	-18.9	-57.1	**7.8**	-16.4	-59.6	**5.8**
N–6	-12.8	-63.2	**3.8**	-10.8	-65.2	**3.0**	-19.3	-56.7	**8.1**	-19.3	-56.7	**8.1**	-13.3	-62.7	**4.0**
N–5	-18.0	-58.0	**6.9**	-11.5	-64.5	**3.3**	-21.5	-54.5	**10.3**	-21.5	-54.5	**10.3**	-14	-62.0	**4.3**
N–4	-22.8	-53.2	**11.8**	-17.3	-58.7	**6.3**	-21.8	-54.2	**10.5**	-21.8	-54.2	**10.5**	-19.3	-56.7	**7.9**
N–3	-27.4	-48.6	**19.9**	-25.9	-50.1	**16.7**	-24.4	-51.6	**14.1**	-24.9	-51.1	**14.9**	-26.4	-49.6	**17.7**
N–2	-31.3	-44.7	**30.8**	-34.8	-41.2	**46.1**	-32.3	-43.7	**34.5**	-31.8	-44.2	**32.6**	-34.3	-41.7	**43.5**
N–1	-40.8	-35.2	**91.0**	-41.8	-34.2	**102.1**	-40.3	-35.7	**85.9**	-39.3	-36.7	**76.5**	-39.3	-36.7	**76.5**
N+1	-49.0	-27.0	**229.0**	-39.0	-37.0	**72.4**	-40.0	-36.0	**81.3**	-37.5	-38.5	**60.9**	-39.5	-36.5	**76.7**
N+2	-32.3	-43.7	**33.1**	-31.3	-44.7	**29.5**	-31.3	-44.7	**29.5**	-30.3	-45.7	**26.3**	-32.8	-43.2	**35.1**
N+3	-23.8	-52.2	**12.3**	-21.8	-54.2	**9.8**	-26.8	-49.2	**17.4**	-21.3	-54.7	**9.2**	-23.8	-52.2	**12.3**
N+4	-27.2	-48.8	**18.1**	-14.7	-61.3	**4.3**	-24.2	-51.8	**12.8**	-15.7	-60.3	**4.8**	-18.2	-57.8	**6.4**
N+5	-14.6	-61.4	**4.2**	-15.1	-60.9	**4.4**	-27.1	-48.9	**17.7**	-13.6	-62.4	**3.7**	-14.6	-61.4	**4.2**
N+6	-12.1	-63.9	**3.1**	-10.6	-65.4	**2.6**	-15.6	-60.4	**4.7**	-10.6	-65.4	**2.6**	-11.1	-64.9	**2.8**
N+7	-32.1	-43.9	**30.8**	-10.6	-65.4	**2.6**	-23.1	-52.9	**10.9**	-11.1	-64.9	**2.7**	-12.6	-63.4	**3.3**
N+8	-11.5	-64.5	**2.9**	-10.0	-66.0	**2.4**	-10.0	-66.0	**2.4**	-10.0	-66.0	**2.4**	-11.0	-65.0	**2.7**
N+9	-11.5	-64.5	**2.8**	-11.0	-65.0	**2.7**	-9.5	-66.5	**2.2**	-10.0	-66.0	**2.4**	-11.5	-64.5	**2.8**
N+10	-17.3	-58.7	**5.5**	-8.8	-67.2	**2.0**	-9.3	-66.7	**2.2**	-8.8	-67.2	**2.0**	-10.8	-65.2	**2.6**
N+11	-13.4	-62.6	**3.4**	-10.4	-65.6	**2.4**	-8.9	-67.1	**2.1**	-9.4	-66.6	**2.2**	-10.9	-65.1	**2.6**
N+12	-12.4	-63.6	**3.0**	-10.4	-65.6	**2.4**	-8.9	-67.1	**2.0**	-9.9	-66.1	**2.3**	-10.9	-65.1	**2.6**
N+13	-13.7	-62.3	**3.5**	-11.2	-64.8	**2.6**	-8.7	-67.3	**2.0**	-9.2	-66.8	**2.1**	-11.7	-64.3	**2.8**
N+14	-41.4	-34.6	**84.3**	-16.4	-59.6	**4.7**	-38.9	-37.1	**63.2**	-29.4	-46.6	**21.2**	-20.9	-55.1	**8.0**
N+15	-14.2	-61.8	**5.0**	-3.2	-72.8	**1.4**	-9.7	-35.1	**3.0**	-6.2	-45.6	**2.0**	-4.2	-54.1	**1.6**

Table 20 – Unfiltered DTV into 7 dB above Edge of DTV Contour Fixed DTV on Channel 32

Undesired DTV Channel	Receiver 1			Receiver 2			Receiver 3			Receiver 4			Receiver 5		
	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)
N–15	-11.3	-56.7	**2.6**	> 11.7	< -79.7	**< 0.2**	-4.3	-63.7	**1.2**	7.7	-75.7	**0.3**	0.2	-68.2	**0.7**
N–14	-11.3	-56.7	**2.6**	> 11.7	< -79.7	**< 0.2**	-9.3	-58.7	**2.1**	1.7	-69.7	**0.6**	0.2	-68.2	**0.7**
N–13	-11.4	-56.6	**2.7**	> 11.6	< -79.6	**< 0.2**	-13.9	-54.1	**3.6**	-2.9	-65.1	**1.0**	-0.4	-67.6	**0.8**
N–12	-11.8	-56.2	**2.8**	11.2	-79.2	**0.2**	-11.8	-56.2	**2.8**	-1.3	-66.7	**0.8**	-0.3	-67.7	**0.7**
N–11	-12.4	-55.6	**3.0**	9.1	-77.1	**0.3**	-12.4	-55.6	**3.0**	-3.4	-64.6	**1.1**	-0.9	-67.1	**0.8**
N–10	-13.0	-55.0	**3.2**	7.5	-75.5	**0.3**	-14.5	-53.5	**3.8**	-8.0	-60.0	**1.8**	-2.0	-66.0	**0.9**
N–9	-12.9	-55.1	**3.2**	5.6	-73.6	**0.4**	-15.9	-52.1	**4.5**	-8.9	-59.1	**2.0**	-3.4	-64.6	**1.1**
N–8	-12.8	-55.2	**3.1**	5.7	-73.7	**0.4**	-17.3	-50.7	**5.3**	-11.3	-56.7	**2.6**	-5.8	-62.2	**1.4**
N–7	-12.3	-55.7	**3.0**	8.7	-76.7	**0.3**	-18.8	-49.2	**6.2**	-13.3	-54.7	**3.3**	-8.8	-59.2	**2.0**
N–6	-12.3	-55.7	**3.0**	2.2	-70.2	**0.6**	-19.3	-48.7	**6.6**	-14.3	-53.7	**3.7**	-1.8	-66.2	**0.9**
N–5	-15.3	-52.7	**4.2**	-4.8	-63.2	**1.2**	-7.3	-60.7	**1.7**	-15.8	-52.2	**4.4**	-2.3	-65.7	**0.9**
N–4	-22.3	-45.7	**9.3**	-12.8	-55.2	**3.1**	-19.8	-48.2	**7.0**	-15.3	-52.7	**4.2**	-8.8	-59.2	**2.0**
N–3	-26.7	-41.3	**15.5**	-21.2	-46.8	**8.2**	-22.7	-45.3	**9.8**	-11.2	-56.8	**2.6**	-16.7	-51.3	**4.9**
N–2	-27.4	-40.6	**16.8**	-28.9	-39.1	**20.0**	-17.4	-50.6	**5.3**	-16.9	-51.1	**5.0**	-23.9	-44.1	**11.2**
N–1	-37.7	-30.3	**55.0**	-35.2	-32.8	**41.3**	-31.2	-36.8	**26.0**	-28.2	-39.8	**18.4**	-29.2	-38.8	**20.7**
N+1	-40.5	-27.5	**75.9**	-30.0	-38.0	**22.7**	-30.5	-37.5	**24.0**	-27.5	-40.5	**17.0**	-31.0	-37.0	**25.4**
N+2	-30.9	-37.1	**25.1**	-18.4	-49.6	**6.0**	-15.4	-52.6	**4.2**	-6.4	-61.6	**1.5**	-19.4	-48.6	**6.7**
N+3	-22.4	-45.6	**9.5**	-5.9	-62.1	**1.4**	-21.9	-46.1	**8.9**	-8.4	-59.6	**1.9**	-7.9	-60.1	**1.8**
N+4	-23.4	-44.6	**10.6**	-1.4	-66.6	**0.8**	-21.4	-46.6	**8.4**	-10.9	-57.1	**2.5**	-7.9	-60.1	**1.8**
N+5	-13.3	-54.7	**3.3**	-6.8	-61.2	**1.6**	-24.3	-43.7	**11.8**	-8.8	-59.2	**2.0**	-8.8	-59.2	**2.0**
N+6	-12.3	-55.7	**3.0**	2.2	-70.2	**0.6**	-13.8	-54.2	**3.5**	1.2	-69.2	**0.6**	-3.8	-64.2	**1.1**
N+7	-32.9	-35.1	**31.7**	3.6	-71.6	**0.5**	-22.4	-45.6	**9.5**	-1.4	-66.6	**0.8**	-10.4	-57.6	**2.4**
N+8	-14.1	-53.9	**3.6**	6.4	-74.4	**0.3**	-0.6	-67.4	**0.8**	7.9	-75.9	**0.3**	-1.6	-66.4	**0.9**
N+9	-13.3	-54.7	**3.3**	6.7	-74.7	**0.3**	0.2	-68.2	**0.7**	7.2	-75.2	**0.3**	-1.3	-66.7	**0.8**
N+10	-13.4	-54.6	**3.4**	2.1	-70.1	**0.6**	-1.4	-66.6	**0.8**	4.1	-72.1	**0.4**	-3.4	-64.6	**1.1**
N+11	-13.8	-54.2	**3.5**	9.7	-77.7	**0.2**	3.7	-71.7	**0.5**	9.2	-77.2	**0.2**	-0.8	-67.2	**0.8**
N+12	-13.3	-54.7	**3.3**	11.2	-79.2	**0.2**	> 11.7	< -79.7	**< 0.2**	11.2	-79.2	**0.2**	-0.3	-67.7	**0.7**
N+13	-13.2	-54.8	**3.3**	> 11.8	< -79.8	**< 0.2**	> 11.8	< -79.8	**< 0.2**	11.3	-79.3	**0.2**	0.3	-68.3	**0.7**
N+14	-32.4	-35.6	**29.9**	-6.4	-61.6	**1.5**	-29.9	-38.1	**22.4**	-20.4	-47.6	**7.5**	-10.9	-57.1	**2.5**
N+15	-36.4	-31.6	**47.4**	-8.4	-59.6	**1.9**	-32.9	-35.1	**31.7**	-21.4	-46.6	**8.4**	-12.4	-55.6	**3.0**

Table 21 – Filtered Fixed DTV on Channel 46 into Weak DTV

Undesired DTV Channel	Receiver 1			Receiver 2			Receiver 3			Receiver 4			Receiver 5		
	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)	Und. Level (dBm)	D/U (dB)	Dist. "r" (m)
N–15	-13.3	-62.7	**3.3**	Fail	Fail	**-**	-6.3	-69.7	**1.5**	3.2	-79.2	**0.5**	-0.3	-75.7	**0.7**
N–14	-13.8	-62.2	**3.5**	Fail	Fail	**-**	-12.3	-63.7	**3.0**	-0.8	-75.2	**0.8**	-0.3	-75.7	**0.7**
N–13	-14.4	-61.6	**3.8**	Fail	Fail	**-**	-16.9	-59.1	**5.0**	-5.4	-70.6	**1.3**	-1.4	-74.6	**0.8**
N–12	-14.8	-61.2	**3.9**	8.7	-84.7	**0.3**	-13.3	-62.7	**3.3**	-4.3	-71.7	**1.2**	-0.8	-75.2	**0.8**
N–11	-14.9	-61.1	**4.0**	2.6	-78.6	**0.5**	-14.4	-61.6	**3.8**	-5.9	-70.1	**1.4**	-1.4	-74.6	**0.8**
N–10	-15.0	-61.0	**4.0**	6.0	-82.0	**0.4**	-17.5	-58.5	**5.4**	-11.0	-65.0	**2.5**	-2.5	-73.5	**1.0**
N–9	-14.9	-61.1	**4.0**	4.6	-80.6	**0.4**	-17.9	-58.1	**5.6**	-11.4	-64.6	**2.7**	-3.9	-72.1	**1.1**
N–8	-14.8	-61.2	**3.9**	3.2	-79.2	**0.5**	-19.3	-56.7	**6.6**	-13.8	-62.2	**3.5**	-6.3	-69.7	**1.5**
N–7	-14.3	-61.7	**3.7**	0.7	-76.7	**0.7**	-21.3	-54.7	**8.3**	-15.8	-60.2	**4.4**	-9.3	-66.7	**2.1**
N–6	-13.8	-62.2	**3.5**	-6.3	-69.7	**1.5**	-21.8	-54.2	**8.8**	-17.3	-58.7	**5.3**	-10.8	-65.2	**2.5**
N–5	-17.8	-58.2	**5.6**	-13.3	-62.7	**3.3**	-20.8	-55.2	**7.9**	-17.3	-58.7	**5.3**	-10.8	-65.2	**2.5**
N–4	-23.8	-52.2	**11.1**	-20.8	-55.2	**7.9**	-22.8	-53.2	**9.9**	-19.3	-56.7	**6.6**	-17.8	-58.2	**5.6**
N–3	-28.2	-47.8	**18.4**	-29.2	-46.8	**20.7**	-24.2	-51.8	**11.6**	-19.7	-56.3	**6.9**	-26.2	-49.8	**14.6**
N–2	-28.4	-47.6	**18.9**	-37.4	-38.6	**53.1**	-26.4	-49.6	**15.0**	-24.9	-51.1	**12.6**	-32.4	-43.6	**29.9**
N–1	-40.2	-35.8	**73.4**	-43.7	-32.3	**109.8**	-39.2	-36.8	**65.4**	-35.7	-40.3	**43.7**	-37.2	-38.8	**51.9**
N+1	-48.0	-28.0	**180.1**	-39.0	-37.0	**63.9**	-39.0	-37.0	**63.9**	-36.0	-40.0	**45.7**	-38.0	-38.0	**57.0**
N+2	-31.4	-44.6	**26.6**	-26.9	-49.1	**15.9**	-23.9	-52.1	**11.2**	-14.9	-61.1	**4.0**	-28.4	-47.6	**18.9**
N+3	-22.9	-53.1	**10.0**	-14.4	-61.6	**3.8**	-24.4	-51.6	**12.6**	-10.4	-65.6	**2.4**	-17.9	-58.1	**5.6**
N+4	-27.9	-48.1	**17.8**	-9.9	-66.1	**2.2**	-23.9	-52.1	**11.2**	-14.9	-61.1	**4.0**	-15.9	-60.1	**4.5**
N+5	-14.8	-61.2	**3.9**	-9.8	-66.2	**2.2**	-27.3	-48.7	**16.6**	-11.3	-64.7	**2.6**	-12.8	-63.2	**3.1**
N+6	-12.8	-63.2	**3.1**	0.7	-76.7	**0.7**	-16.3	-59.7	**4.7**	-0.8	-75.2	**0.8**	-9.8	-66.2	**2.2**
N+7	-33.9	-42.1	**35.5**	2.6	-78.6	**0.5**	-24.4	-51.6	**11.9**	-3.9	-72.1	**1.1**	-11.4	-64.6	**2.7**
N+8	-14.1	-61.9	**3.6**	5.9	-81.9	**0.4**	-4.1	-71.9	**1.1**	7.4	-83.4	**0.3**	-2.1	-73.9	**0.9**
N+9	-13.8	-62.2	**3.5**	5.7	-81.7	**0.4**	-2.3	-73.7	**0.9**	5.7	-81.7	**0.4**	-2.3	-73.7	**0.9**
N+10	-13.9	-62.1	**3.6**	-0.4	-75.6	**0.8**	-4.4	-71.6	**1.2**	1.6	-77.6	**0.6**	-5.9	-70.1	**1.4**
N+11	-14.8	-61.2	**3.9**	6.7	-82.7	**0.3**	Fail	Fail	**--**	6.7	-82.7	**0.3**	-1.3	-74.7	**0.8**
N+12	-13.8	-62.2	**3.5**	10.7	-86.7	**0.2**	> 11.7	< -87.7	**< 0.2**	10.7	-86.7	**0.2**	-0.8	-75.2	**0.8**
N+13	-13.7	-62.3	**3.5**	> 11.8	< -87.8	**< 0.2**	6.8	-82.8	**0.3**	10.3	-86.3	**0.2**	-0.7	-75.3	**0.8**
N+14	-40.9	-35.1	**79.9**	-15.4	-60.6	**4.2**	-38.9	-37.1	**63.2**	-29.4	-46.6	**21.2**	-20.4	-55.6	**7.5**
N+15	-45.4	-30.6	**133.5**	-16.9	-59.1	**5.0**	-41.9	-34.1	**89.2**	-30.4	-45.6	**23.7**	-21.4	-54.6	**8.4**

Table 22 – Filtered Fixed DTV on Channel 46 into 7 dB above Edge of DTV Contour DTV

4.4 Calculations for Interference Distance from a Radiating Device in the Presence of another Interference to the Desired DTV Channel

In this section, the interference distance from a radiating device is calculated when another DTV into DTV adjacent channel interference is already present for the desired DTV channel.

To perform the corresponding tests, the power level of an undesired DTV adjacent channel is set to bring a DTV receiver to TOV – 3 dB. This means that an increase of 3 dB in the power of the undesired DTV channel would cause TOV for the DTV receiver. Then a second undesired DTV adjacent channel is introduced and its power level is increased to bring the DTV receiver to TOV. The two undesired DTV channels are set to operate on two different adjacent channels (e.g. “N–1 and N+1”, “N+2 and N+3”, etc.).

Using the results of the above tests, the distance at which a radiating device can produce the same power level as the second undesired DTV channel, has been calculated.

The following tables (tables 23 to 28) present the test results for different undesired adjacent channel combinations along with the calculated values of interference distance of a radiating device.

As in the previous section, the radiating device is assumed to be a point radiator with 100-mW output power and 6-dBi transmitting antenna gain (maximum radiated power of 26 dBm). The DTV receiving antenna is assumed to have 0-dBi gain, to be matched with the load or transmission line to which it is connected, and to have the same polarization as the incident wave.

Appendix 2 represents all the relations and the procedures that have been used, and all the assumptions that have been made to carry out the calculations.

Test Conditions		Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
Desired: – 68 dBm	**Ch-43**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**
Undesired #1 (U1): N+3	**Ch-46**										
Undesired #2 (U2): N-3	**Ch-40**										
Single Undesired into DTV											
U1 at TOV only		-21.7	-46.3	-6.2	-61.8	-24.2	-43.8	-8.7	-59.3	-7.7	-60.3
U2 at TOV only		-27.9	-40.1	-23.9	-44.1	-24.4	-43.6	-23.4	-44.6	-23.4	-44.6
Multiple Undesired into DTV											
U2 at TOV In presence of U1 – 3dB		-29.4	-38.6	-26.4	-41.6	-41.4	-26.6	-39.4	-28.6	-26.9	-41.1
Degradation *		**1.5 dB**		**2.5 dB**		**17.0 dB**		**16.0 dB**		**3.5 dB**	
U2 Interference distance *		**22.4 (meters)**		**15.8 (meters)**		**89.1 (meters)**		**70.8 (meters)**		**16.8 (meters)**	

* Calculated values

Table 23, N+3 and N-3 into Weak DTV

Test Conditions		Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
Desired: – 68 dBm	**Ch-43**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**
Undesired #1 (U1): N+3	**Ch-46**										
Undesired #2 (U2): N-4	**Ch-39**										
Single Undesired into DTV											
U1 at TOV only		-22.1	-45.9	-5.6	-62.4	-24.6	-43.4	-8.6	-59.4	-7.6	-60.4
U2 at TOV only		-23.6	-44.4	-10.1	-57.9	-20.1	-47.9	-15.1	-52.9	-10.1	-57.9
Multiple Undesired into DTV											
U2 at TOV In presence of U1 – 3dB		-48.1	-19.9	-14.6	-53.4	-36.1	-31.9	-36.6	-31.4	-21.6	-46.4
Degradation *		**24.5 dB**		**4.5 dB**		**16.0 dB**		**21.5 dB**		**11.5 dB**	
U2 Interference distance *		**194.5 (meters)**		**4.1 (meters)**		**48.9 (meters)**		**51.8 (meters)**		**9.2 (meters)**	

* Calculated values

Table 24, N+3 and N-4 into Weak DTV

Test Conditions		Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
Desired: – 68 dBm	**Ch-44**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**
Undesired #1 (U1): N+2	**Ch-46**										
Undesired #2 (U2): N+3	**Ch-47**										
Single Undesired into DTV											
U1 at TOV only		-30.5	-37.5	-18.5	-49.5	-15.0	-53.0	-6.0	-62	-18.5	-49.5
U2 at TOV only		-21.6	-46.4	-13.1	-54.9	-24.1	-43.9	-12.6	-55.4	-13.6	-54.4
Multiple Undesired into DTV											
U2 at TOV In presence of U1 – 3dB		-27.6	-40.4	-15.6	-52.4	-27.6	-40.4	-25.1	-42.9	-16.6	-51.4
Degradation *		**6.0 dB**		**2.5 dB**		**3.5 dB**		**12.5 dB**		**3.0 dB**	
U2 Interference distance *		**17.1 (meters)**		**4.3 (meters)**		**17.1 (meters)**		**12.8 (meters)**		**4.8 (meters)**	

* Calculated values

Table 25, N+2 and N+3 into Weak DTV

Test Condition		Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
Desired: – 68 dBm	**Ch-44**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**
Undesired #1 (U1): N+2	**Ch-46**										
Undesired #2 (U2): N+4	**Ch-48**										
Single Undesired into DTV											
U1 at TOV only		-30.5	-37.5	-18.5	-49.5	-15.0	-53.0	-6.5	-61.5	-19.0	-49.0
U2 at TOV only		-22.8	-45.2	-7.8	-60.2	-20.3	-47.7	-10.8	-57.2	-9.3	-58.7
Multiple Undesired into DTV											
U2 at TOV In presence of U1 – 3dB		-31.3	-36.7	-9.3	-58.7	-31.8	-36.2	-33.3	-34.7	-17.3	-50.7
Degradation *		**8.5 dB**		**1.5 dB**		**11.5 dB**		**22.5 dB**		**8.0 dB**	
U2 Interference distance *		**25.9 (meters)**		**2.1 (meters)**		**27.4 (meters)**		**32.6 (meters)**		**5.2 (meters)**	

* Calculated values

Table 26, N+2 and N+4 into Weak DTV

Test Conditions		Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
Desired: – 68 dBm	**Ch-43**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**
Undesired #1 (U1): N+3	**Ch-46**										
Undesired #2 (U2): N+6	**Ch-49**										
Single Undesired into DTV											
U1 at TOV only		-22.0	-46.0	-6.0	-62.0	-24.5	-43.5	-8.5	-59.5	-8.0	-60.0
U2 at TOV only		-13.3	-54.7	-2.3	-65.7	-13.3	-54.7	-1.8	-66.2	-4.8	-63.2
Multiple Undesired into DTV											
U2 at TOV In presence of U1 – 3dB		-42.8	-25.2	-22.3	-45.7	-44.8	-23.2	-35.8	-32.2	-37.8	-30.2
Degradation *		**29.5 dB**		**20.0 dB**		**31.5 dB**		**34.0 dB**		**33.0 dB**	
U2 Interference distance *		**96.4 (meters)**		**9.1 (meters)**		**121.4 (meters)**		**43.1 (meters)**		**54.2 (meters)**	

* Calculated values

Table 27, N+3 and N+6 into Weak DTV

Test Conditions		Receiver 1		Receiver 2		Receiver 3		Receiver 4		Receiver 5	
Desired: – 68 dBm	**Ch-39**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**	**Undesired Signal Level (dBm)**	**D/U (dB)**
Undesired #1 (U1): N+7	**Ch-46**										
Undesired #2 (U2): N+14	**Ch-53**										
Single Undesired into DTV											
U1 at TOV only		-32.5	-35.5	3.5	-71.5	-19.5	-48.5	-1.5	-66.5	-10.0	-58.0
U2 at TOV only		-35.5	-32.5	-10.5	-57.5	-30.0	-38.0	-19.5	-48.5	-12.0	-56.0
Multiple Undesired into DTV											
U2 at TOV In presence of U1 – 3dB		-38.0	-30.0	-35.0	-33.0	-32.0	-36.0	-29.0	-39.0	-36.5	-31.5
Degradation *		**2.5 dB**		**24.5 dB**		**2.0 dB**		**9.5 dB**		**24.5 dB**	
U2 Interference distance *		**53.6 (meters)**		**37.9 (meters)**		**26.9 (meters)**		**19.0 (meters)**		**45.1 (meters)**	

* Calculated values

Table 28, N+7 and N+14 into Weak DTV

5 Conclusion

The Communications Research Centre Canada (CRC) carried out laboratory tests to evaluate the performance of five VSB receivers. The results of these tests indicate:

- There can be substantial differences in interference performance of different VSB receivers and interference mechanisms, regardless of age and vintage.
- Interfering signals on the upper and lower first adjacent channel are the most problematic and consistently result in large calculated interference distances “r” at which the interfering device can cause a DTV receiver to reach TOV.
- In general, interfering signals on the second and third adjacent channels can also be problematic and result in calculated interference distances “r” larger than 10 meters.
- Image interference on channels +7, +14 and +15 can also result at significant distances under certain circumstances for certain receivers.
- Multiple interfering signals reduce the D/U ratios. The worst case appears to be N+x and N+2x. Degradation of more than 30 dB and more have been measured on some receivers.

Appendix 1
List of the Receivers under Test

Receiver #	Type	Manufactured Year
1	Consumer	2001
2	Consumer	2002
3	PC Plug-in Card	2005
4	Consumer	2003
5	Consumer	2006

Appendix 2
Calculations of distance "r"

Relation between the radiated power from an isotropic point source in free space and the power at the output of a receiving antenna located at a distance "r" from the radiator

Section 1: Relation between the incident electric field and the power at the output of the receiving antenna

Relation between the incident electric field intensity Ei (rms) and the voltage V_L (rms) across the load R_L, to which the antenna is connected, can be written as [1]:

$$\mathbf{Ei\ (dB\mu V/m) = V_L\ (dB\mu V) + 20 \log F\ (MHz) - Gant\ (dBi) - 10 \log R_L\ (\Omega) - 10 \log p - 10 \log q - 12.8} \quad (1.1)$$

In this relation "Gant" is the isotropic gain (dBi) of the receiving antenna. It should be noted, however, that if the receiving antenna is directional (with maximum gain of "Gant (dBi)"), but it is not directed toward the transmitter, then the decrease in gain due to this "off-direction" should be subtracted from Gant before inserting it in the equation.

"p" is polarization match factor and is 1 (or 10 log p = 0 dB) when the incident wave and the antenna both have the same polarization.

"q" is the impedance match factor and is equal to 1 if the antenna is matched with the transmission line or the load to which it is connected. In case of mismatch, its value can be found in terms of antenna and load impedance, or the Voltage Standing Wave Ratio (VSWR) of the antenna [2].

It is also common to relate **Ei** and $\mathbf{V_L}$ in terms of Antenna Factor (**AF**). To do this, equation (1.1) can be rewritten as:

$$Ei\ (dB\mu V/m) = V_L\ (dB\mu V) + AF \quad (1.2)$$

$$AF = 20 \log F\ (MHz) - Gant\ (dBi) - 10 \log R_L\ (\Omega) - 10 \log p - 10 \log q - 12.8$$

[1] Warren L. Stutzman and Gary A. Thiele, "Antenna Theory and Design", chapter 9, copyright 1998 John Wiley and sons, ISBN 0-471-02590-9

[2] In case of mismatch between the receiving antenna and the load to which it is connected, "q" can be found as:

$$q = 4 R_A R_L \,/\, [\,(R_A + R_L)^2 + (X_A + X_L)^2\,]$$

Where "R" is the real and "X" is the imaginary part of the impedance and suffixes A and L are for Antenna and Load. Perfect match is when $R_A = R_L$ and $X_A = -X_L$ (conjugate match).
"q" can also be found from VSWR of the antenna as:

$$q = 1 - [\,(VSWR - 1) \,/\, (VSWR + 1)\,]^2$$

Section 2: Relation between the power radiated from an isotropic point source in free space and the resultant electric field at a distance "r"

For a point source (isotropic radiator) in free space, power density W (Watt/sq. meter) is [3]:

$$\mathbf{W = Prad / 4\,\pi\, r^2 = E^2 / 120\,\pi} \qquad (2.1)$$

Where Prad is the total **radiated power** (Watts) from the point source, E is the free space electric field (V/m), and r is the radial distance from the radiator (meter).

It should be noted, however, that Prad in this equation represents the radiated power at the output of the transmitting antenna (which here is assumed to be an isotropic point radiator) and so, factors such as efficiency, mismatch, etc. of the transmitting antenna have not been taken into account. From equation 2.1 we can get:

$$E^2 = 30\ Prad / r^2$$

This equation in turn leads to:

$$\mathbf{E\ (dB\mu V/m) = Prad\ (dBm) - 20\ log\ r\ (meter) + 104.77} \qquad (2.2)$$

Section 3: Relation between the power radiated from an isotropic point source in free space and the resultant power at the output of a receiving antenna

Replacing "Ei" in equation 1.1 with "E" obtained from equation 2.2, we can relate the voltage across the load (to which the receiving antenna is connected) with the power radiated from the point source through the following equation:

$$\mathbf{V_L\ (dB\mu V) = Prad\ (dBm) - 20\ log\ r\ (meter) - 20\ log\ F\ (MHz) + Gant\ (dBi) + 10\ log\ R_L\ (\Omega) + 10\ log\ q + 10\ log\ p + 117.57} \qquad (3.1)$$

The output voltage of the antenna ($\mathbf{V_L}$) can also be converted to the power ($\mathbf{P_L}$) delivered to the load ($\mathbf{R_L}$). Using $P = V^2 / R$, we can get:

$$V_L\ (dB\mu V) = P_L\ (dBm) + 10\ log\ R_L\ (\Omega) + 90 \qquad (3.2)$$

Replacing $\mathbf{V_L}$ in equation 3.1 with the one obtained from equation 3.2, we can relate the power ($\mathbf{P_L}$) delivered by a receiving antenna to the load (to which it is connected), and the power radiated from the point source (**Prad**) through the following equation:

$$\mathbf{P_L\ (dBm) = Prad\ (dBm) - 20\ log\ r\ (meter) - 20\ log\ F\ (MHz) + Gant\ (dBi) + 10\ log\ q + 10\ log\ p + 27.57} \qquad (3.3)$$

[3] W. Daniel and E. W, Allen, "Television Engineering Handbook", chapter 6
copyright 1992 McGraw-Hill Inc., ISBN 0-07-004788-X

Section 4: Calculating the distance from a point radiator at which the desired TV channel is at TOV

Equation 3.3 (rewritten as equation 4.1 below) is used for calculating the distance "r" from a point radiator at which the desired TV channel is at TOV.

$$\mathbf{20 \log r\ (meter) = Prad\ (dBm) - P_L\ (dBm) - 20 \log F\ (MHz) + Gant\ (dBi) + 10 \log p + 10 \log q + 27.57} \quad (4.1)$$

In this equation, $\mathbf{P_L}$ is the power delivered to the load connected to the receiving antenna. If we replace it with the power of the undesired DTV channel that causes TOV for the desired channel (obtained from the tests), then the value of "**r**" obtained from the above equation represents the distance at which the radiator causes TOV for the desired DTV channel. At distances closer to the radiator, interference to the desired DTV channel would be more and reception failure could be expected. It should be noted, however, that this way of finding "**r**" is valid only if one radiator is operating in the vicinity of the TV receiver in the whole 6 MHz bandwidth of the corresponding adjacent TV channel. For more than one radiator, their cumulative effect should be taken into account.

It should be noted, however, that the cumulative interference of more than one radiator into the desired DTV channel can sometimes be much worse than that anticipated by simple mathematical power adding rules. This is because the aggregate interference actually depends on some non-linear mechanisms. One such mechanism is that due to receiver's nonlinearity, multiple interferences can result in inter-modulation products.

For example, two equal power and equal distance radiators are mathematically expected to create about 3-dB higher interference into the DTV receiver. But if the two radiators are operating on two adjacent channels separated by 6 or 7 DTV channels, then their inter-modulation products can interfere with the IF processing in the receiver. Depending on the specific receiver's response, this can result in much more than 3-dB degradation. The test results of multiple-interference clearly demonstrate such phenomena.

Assuming a point radiator with 100-mW output power and 6-dBi transmitting antenna gain, the maximum radiated power would be 400-mW (26 dBm). For these calculations, **Prad** is taken to be 26 dBm and to balance such assumption, the DTV receiving antenna gain is taken to be zero (Gant = 0 dBi).

Further assuming that the receiving antenna is matched with the load (to which it is connected) and has the same polarization as the incident wave, then 10 log p = 10 log q = 0 and we can rewrite (4.1) as:

$$\mathbf{20 \log r\ (meter) = 53.57 - P_L\ (dBm) - 20 \log F\ (MHz)} \quad (4.2)$$

If the desired channel is fixed and undesired channel is taken from N–15 to N+15, then "20 log F" should be calculated and inserted in the equation for each undesired channel.

If undesired channel is fixed and the desired channel is taken from N–15 to N+15, then "20 log F" in the above equations is fixed and equal to "20 log (centre freq. of undesired channel).

It should be noted, however, that channels N-15 or N+15 in the tables mean that the undesired channel is taken to be 15 channels less or more than the desired channel respectively. So, in the case of fixed desired (on Ch-32), channels N-15 to N+15 are representing channels 17 to 47. But in the case of fixed undesired (on Ch-46), N-15 is actually channel 61 (as the desired channel is on Ch-61 and undesired channel on Ch-46), and N+15 is Ch-31 (as the desired channel is on Ch-31 and undesired channel is Ch-46).

EXHIBIT C

Laboratory Evaluation of Unlicensed Devices Interference to NTSC and ATSC DTV Systems in the UHF Band

Phase II

FINAL REPORT

by

The Communication Research Centre Canada
(CRC)

for

The Association of Maximum Service Television
(MSTV)

May 2005

Table of Contents

1. Introduction

On May 25, 2004, the FCC released a Notice of Proposed Rule Making (NPRM) that proposes to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used. CRC was contracted by MSTV to conduct measurements to investigate the possible impact of interference from the unlicensed devices on the current DTV and NTSC services.

Based on the FCC NPRM, the proposed Unlicensed Devices (UD) "radiated emissions that fall outside the TV broadcast channel(s) where the device operates must comply with the radiated emission limits specified in §15.209(a)". Section 15.209(a) of the FCC rules state that "*the radiated emission limits over frequency band of 215-960 MHz is 200 dBμV/m at a measurement distance of 3 meters"*. The emission limit is based on measurement employing a CISPR quasi-peak detector with a *measurement bandwidth of 120 kHz.*

Based on the Commission proposal, CRC conducted measurement to characterise the de-sensitisation of ATSC DTV and NTSC receivers from the side-lobe radiated emissions of an unlicensed portable device. Specifically the following laboratory evaluations were performed:

- De-sensitisation of DTV receivers in an indoor environment.
- De-sensitisation of NTSC receivers in an indoor environment.

2. Laboratory Test Set-up

The Unlicensed Devices interference emissions signals were generated using a random noise generator provided by CRC. The UD emission signals were generated by CRC in such a way as to meet the FCC emissions requirement. (i.e. 200 μV/m, or 46 dBμV/m within a 120 kHz bandwidth). The interfering emissions signals were measured at 3 m from the unlicensed devices, within a 120 kHz bandwidth. The UD interfering emitted signal power level was adjusted to 3 dB below the FCC emission requirement to avoid any impact of measurement error on the measurement results. The generated unlicensed devices interference emission signals were filtered and inserted on the desired DTV or NTSC channel. List below is a summary of the relevant parameters and calculations used to conduct these tests:

FCC emission limit: 200 μV/m, or 46 dBμV/m within 120 kHz

Convert to dBm:
$$P_{dBm} = -75.5 + 46\,dB\mu V\ \ m - 20\log(Frequency\ in\ MHz)$$
$$P_{dBm} = -29.5 - 20\log(Frequency\ in\ MHz)$$

Interference signal parameters:
- Random Noise filtered with a bandpass filter;
- 3-dB bandwidth: 30 MHz.

***To avoid measurement error, the interference level is set at 3 dB below the FCC specified limit,* thus**:

- For channels 24 to 26, the interference level is:

$$P_{dBm} = -29.5 - 20\log(539) - 3$$

$$P_{dBm} = -87.1\ dBm\ within\ 120kHz$$

- For channels 52 to 54, the interference level is:

$$P_{dBm} = -29.5 - 20\log(707) - 3$$

$$P_{dBm} = -89.5\ dBm\ within\ 120kHz$$

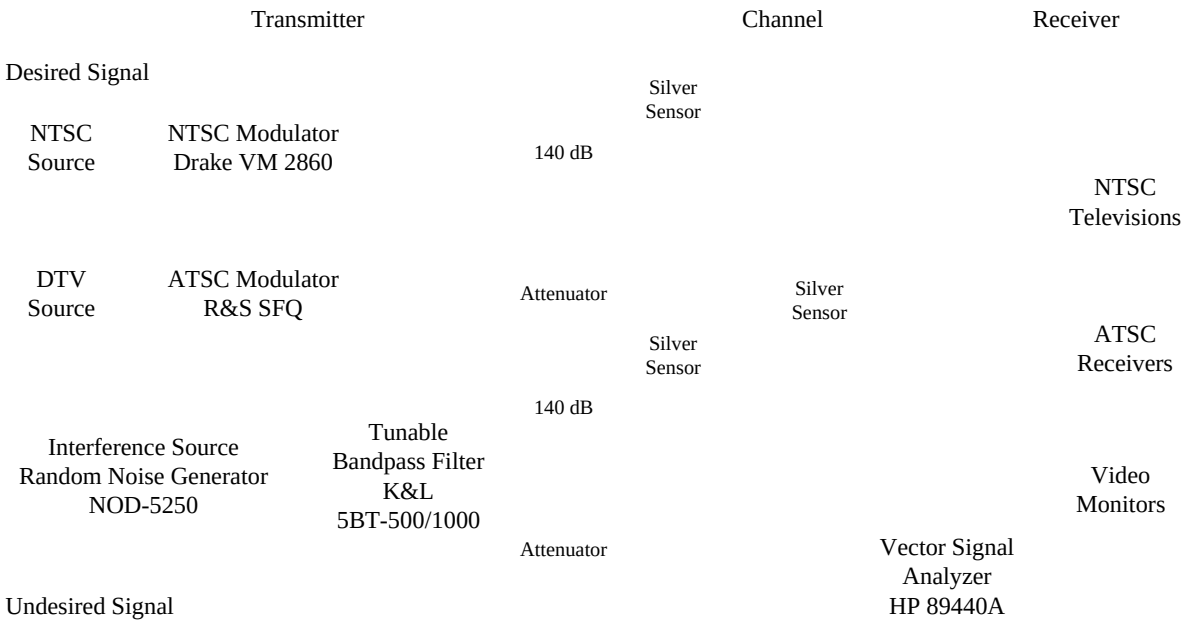


Figure 1. Laboratory Test Set-up for the Evaluation of UD Emissions Impact on TV Signals.

In the above calculation, a simple dipole antenna is assumed. The emission limit field strength is converted into signal power (dBm). In the laboratory test, the interference power level is adjusted by varying the transmission power. The receiving power calibration is done at 3 meters from the emission point for the power levels calculated above.

The laboratory set-up for the evaluation of the ATSC 8-VSB receiver is presented in Figure 1. The set-up is divided into three sections: Transmitter, Channel and Receiver.

The laboratory measurements were conducted at a distance between the UD and the DTV or NTSC receivers of 3 meters. The resulting receiver de-sensitisation measurement was recorded. The test procedures are attached (Annex 1).

The Threshold of Visibility (TOV) was recorded for viewing DTV pictures over a 20 seconds period. The ITU-R Grade 3 performance (slightly annoying audio, video, and colour) for NTSC was recorded. The power levels recorded were in 1-dB step-size.

The tests were conducted using one video sequence for DTV and one video test pattern for NTSC (colour bars). The tests investigated the de-sensitisation effects due to UD interference without and with existing off-air interference.

The tests were done on Off-Air Channels 52 to 54 and 24 to 26. As a reference, Figure 2 and 3 show the off-air spectrum plot of 698-716 MHz and 530-548 MHz. It is noteworthy that there is no other interference source detected in that spectrum band of Figure 2. Figure 3 shows an existing NTSC signal of -57.0 dBm peak power on channel 24.

An UD interference signals were used with a 3 dB bandwidths of 30 MHz. The spectrums of the signals are presented in Figures 4 and 5. Based on the spectrum plots, there is little multipath distortion at a 3 meters site.

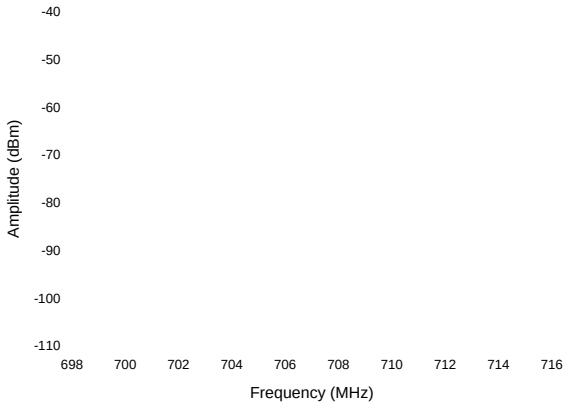


Figure 2. Off-Air Spectrum Plots of Channels 52-54 (698-716 MHz)

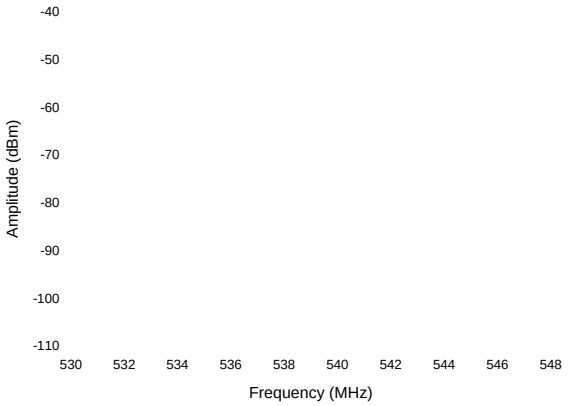


Figure 3. Off-Air Spectrum Plots of Channels 24-26 (530-548 MHz)

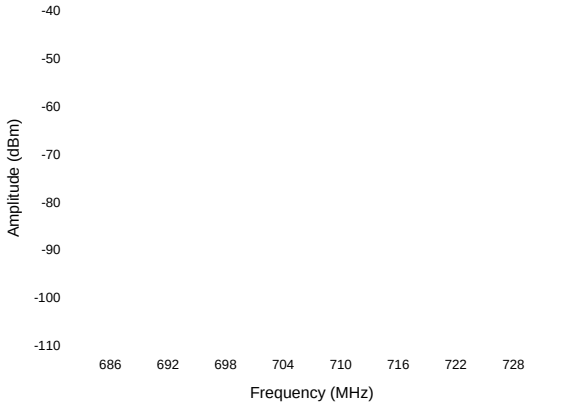


Figure 4. Spectrum of the Filtred Random Noise Signal Source

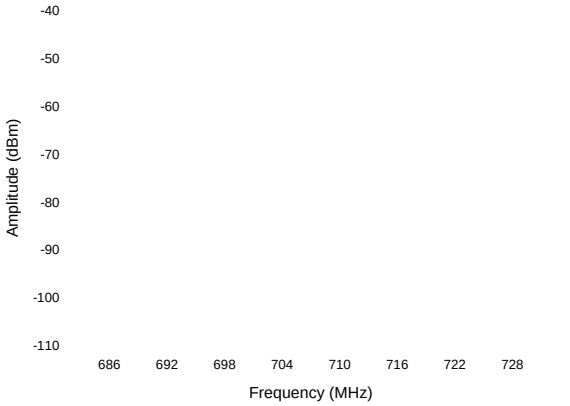


Figure 5. Spectrum of the Filtred Random Noise Signal Received at 3 Meters

3. Results of the Laboratory Test

The results of the following laboratory experiments listed below are presented in this section:

- De-sensitisation of DTV receivers in an indoor environment.
- De-sensitisation of NTSC receivers in an indoor environment.

3.1 De-Sensitisation of DTV Receivers in an Indoor Environment

The DTV signal and the UD sideband signals were transmitted and received in the same room. The calibration was done at a distance of 3 meters from the DTV receiver as specified by the FCC NPRM and explained in the test procedure in Annex 1. For channels 52-54, the interference signal power was adjusted to obtain -89.5 dBm/120 kHz at 3 meters and for channels 24-26, the interference signal power was adjusted to obtain -87.1 dBm/120 kHz at 3 meters.

Only one DTV receiver was used in these tests.

The tests were conducted on Off-Air channels 52-54 (698 – 716 MHz) without any external off-air interference. The tests were also conducted on Off-Air channels 24-26 (530 – 548 MHz) with an existing NTSC signal. The results are presented in Table 1 and 2 for the tests conducted without and with external interference respectively.

Table 1. De-Sensitisation of DTV Receiver #1 at 3 Meters without external interference

Channel	**52**	**53**	**54**
Rx Sensitivity	-76.7 dBm	-78.5 dBm	-78.8 dBm
De-Sensitisation	20.5 dB	21.0 dB	21.0 dB

Table 2. De-Sensitisation of DTV Receiver #1 at 3 Meters with external interference

Channel	**24***	**25**	**26**
Rx Sensitivity	-59.3 dBm	-73.3 dBm	-78.1 dBm
De-Sensitisation	9.5 dB	18.5 dB	22.5 dB

***: The existing interference is a NTSC signal of -57.0 dBm peak power.**

It was noticed that the receiver sensitivity varies in a +/-1 dB range for different test points. This is attributed to one or all of these factors: multipath distortion, noise floor variation, tuner performance, and other interference mechanisms.

It was also observed that signal reflection within the building created standing waves. The result of this phenomenon was that the received signal could be up to 3 dB higher than what it would be for free-space propagation. There were also signal “nulls” in the room, which could result in signal level drops of several dB over small changes in location.

3.2 De-Sensitisation of NTSC Receivers in an Indoor Environment

The NTSC and the interference signals were transmitted and received in the same room. The calibration was done at 3m as explained in the test procedure in Annex 1. For channels 52-54, the interference signal power was adjusted to obtain -89.5 dBm/120 kHz at 3 meters and for channels 24-26, the interference signal power was adjusted to obtain -87.1 dBm/120 kHz at 3 meters.

The de-sensitisation tests were carried out on Off-Air channels 52-54 (698 – 716 MHz) without any external off-air interference. The tests were also conducted on Off-Air channels 24-26 (530 – 548 MHz) with an existing NTSC signal. The results are presented in Tables 3 and 4 for tests conducted without and with external interference respectively.

Table 3. De-Sensitisation of NTSC Receiver #1 at 3 Meters without external interference

Channel	**52**	**53**	**54**
Rx Sensitivity	-61.0 dBm	-60.1 dBm	-62.3 dBm
De-Sensitisation	23.4 dB	23.2 dB	25.1 dB

Table 4. De-Sensitisation of NTSC Receiver #1 at 3 Meters with external interference

Channel	**24***	**25**	**26**
Rx Sensitivity	N/A	-60.6 dBm	-60.0 dBm
De-Sensitisation	N/A	25.5 dB	24.6 dB

***: The existing interference is a NTSC signal of -57.0 dBm peak power.**

The test results show that there is more de-sensitisation for NTSC than that of DTV. This is most likely because the NTSC system requires a higher S/N to operate. But for demonstration at FCC, we recommend using DTV, since the NTSC test using CCIR Grade 3 has a very soft threshold and very difficult for ordinary people to judge.

ANNEX 1: TEST PROCEDURE

Test Procedure for Unlicensed Devices Interference Signal Emissions into the ATSC DTV and NTSC Channel.

Set Up:

- Select an RF channel between CH14 and 69.
  - Make sure there are minimum off-air interference in co- and first adjacent channels.
- Interference emissions signals:
  - Filtered random noise, between 18 and 35 MHz BW.
- Interference signal power level set up:
  - FCC emission requirement: 200 µV/m, or 46 dBµV/m within a 120 kHz BW.
  - Convert to dBm: P(dBm) = -75.5 + dBµV/m – 20 log(Frequency in MHz)
  - The emission signal level should be measured at 3m from the unlicensed devices, within a 120 kHz BW.
  - The signal level should be 3 dB below the above calculated emission level P(dBm) to avoid possible measurement errors. Since allowed interference signal power is calculated and fed to the receiver directly, the type of antenna used for transmission and reception is irrelevant.

- Wanted signal:
  - ATSC and NTSC.
  - TOV, for DTV, and ITU-R Grad 3, for NTSC, are used as the test threshold.
  - Possible test point: 3m, 12m and 18m away from the unlicensed devices.
  - Tests can also be done with signals transmitted thought a wall.
  - Television channel multipath distortion should be minimum.

DTV TEST

1. Test at 3 meters with filtered random noise interference emissions signals:

- At 3m, measure the off-air interference level (co- and first adjacent-channels), and the equipment noise level in 6 MHz and in 120 kHz bandwidth;
- Adjust interference emission signal power level, measured 3m away, to be P(dBm) – 3 dB over the 120 kHz BW;
- Turn off the interference, transmit ATSC DTV, and find TOV, record the transmitted signal power level in 6 MHz and in 120 kHz bandwidth;
- Turn on the interference emission signal. If DTV reception is not possible, increase the DTV signal power level until TOV, record the DTV Tx signal power level in 6 MHz and 120 kHz bandwidth. The difference between the DTV signal power level with and without the interference emission signal is the receiver de-sensitisation.

2. Test at 12 meters:

- Keep the interference emission signal power unchanged and moves the test point to 12m.
- Repeat the 3m test.
- The result will be the de-sensitisation at 12m.

3. Test at 24 meters:

- Keep the interference emission signal power unchanged and moves the test point to 24m,
- Repeat the 3m test.
- The result will be the de-sensitisation at 24m.

NTSC TEST

- Keep the interference emission signal power unchanged, repeat test at 6m, and 18m with NTSC as the wanted signal.
- For narrowband interference test, the interference emission signal should be transmitted at several in-band frequency locations across 6 MHz channel.
- NTSC signal power is measured as peak average power.

EXHIBIT D

Laboratory Evaluation of Unlicensed Devices Interference to NTSC and ATSC DTV Systems in the UHF Band

REPORT

by

The Communication Research Centre Canada
(CRC)

for

The Association of Maximum Service Television
(MSTV)

November 29, 2004

Table of Contents

Executive Summary

This report presents the results of measurement made to assess the interference potential to DTV and NTSC television reception from the side-lobe emissions of an Unlicensed Device (UD) operating in the UHF band, which comply with the Section §15.209(a) of the FCC Rules. Section §15.209 (a) of the FCC Rules specify a radiated emission limit of 200 uV/m at a measurement distance of 3 meters over frequency range of 215-960 MHz. The emission limit is based on measurement employing a International Special Committee on Radio Interference (CISPR) quasi-peak detector with a measurement bandwidth of 120 kHz.

In general, today's ATSC DTV receiver minimum signal level is in the range of –78 dBm to –83 dBm (over 6 MHz BW), which is equivalent to a noise floor of –93 dBm to –98 dBm. Measurement results show that the proposed Unlicensed Device side-lobe emission limit will cause significant de-sensitisation to DTV and NTSC receivers over a wide area. This is because the proposed emission limit is much higher than the receiver equivalent noise floor (–60 dBm to –70 dBm over a 6 MHz BW). The level of de-sensitisation depends on the interference signal power bandwidth, distance to the interference source, receiver performance, and test environment (indoor, outdoor, etc.).

Tests were conducted in an indoor environment to determine the desensitisation to digital television reception from unlicensed device side-lobe radiated emissions in the clear and when the side-lobe radiated emissions are transmitted through a wall. The data shows that for a distance of 3 meters, an unlicensed device operating with signal bandwidths of 5.6 MHz and 0.43 MHz will de-sensitise DTV receivers an average of 24.5 dB and 13.8 dB, respectively. Similarly, at a distance of 12 meters, the average de-sensitisation is 15.2 dB and 5.6 dB respectively. At 24 meters, the average de-sensitisation is 11.4 and 4.1 dB respectively. Moreover, even when a dry wall is separating an unlicensed device and a DTV receiver, an average de-sensitisation of 19.7 dB and 15.2 dB were measured at distances 5 and 12 meters respectively, when the unlicensed device is operating with a signal bandwidth 5.6 MHz.

Similar test were also conducted for NTSC receivers. The data shows that an even greater desensitisation for NTSC, when compared to DTV. For a wideband interference signal (5.6 MHz) at 18meters from an analog television receiver, assuming ITU-R Grade 3 picture quality, the average desensitisation is 15.3 dB. For a narrowband signal (0.43 MHz), the desensitisation will depend on the location of the interference signal relative to the video and colour carrier of the NTSC signal and generally follows the traditional behaviour of the "S" curve. When placed in the middle of the TV channel, the average de-sensitisation at 18 meters is 5.6 dB. At a 6 meters distance, the desensitisation ranges from 5 dB to 18 dB depending on the location of the interference signal relative to the video and colour carrier of the NTSC signal. If the Threshold Of Visibility (TOV) is used as the picture quality threshold, a 10 dB correction (more desensitisation) should be added over the ITU-R Grade 3 case.

The UD could also cause cable ingress, especially for a single shielded RG-59 cable. The ingress level can be up to –44 dBm regardless of whether the cable is terminated or not.

1. Introduction

On May 25, 2004, the FCC released a Notice of Proposed Rule Making (NPRM) that proposes to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used. CRC was contracted by MSTV to conduct measurements to investigate the possible impact of interference from the unlicensed devices on the current DTV and NTSC services.

Based on the FCC NPRM, the proposed Unlicensed Devices (UD) "radiated emissions that fall outside the TV broadcast channel(s) where the device operates must comply with the radiated emission limits specified in §15.209(a)". Section 15.209(a) of the FCC rules state that "*the radiated emission limits over frequency band of 215-960 MHz is 200 dBuV/m at a measurement distance of 3 meters"*. The emission limit is based on measurement employing a CISPR quasi-peak detector with a *measurement bandwidth of 120 kHz.*

Based on the Commission proposal, CRC conducted measurement to characterise the de-sensitisation of ATSC DTV and NTSC receivers from the side-lobe radiated emissions of an unlicensed portable device. Specifically the following laboratory evaluations were performed:

- De-sensitisation of DTV receivers in an indoor environment.
- De-sensitisation of DTV receivers with UD sideband signals transmitted through a dry wall.
- De-sensitisation of NTSC receivers in an indoor environment.
- De-sensitisation of NTSC receivers with the narrowband signal transmitted across the NTSC channel.
- Cable ingress created by the UD signals.

2. Laboratory Test Set-up

The Unlicensed Devices interference emissions signals were generated using a COFDM modulator provided by CRC. The UD emission signals were generated by CRC in such a way as to meet the FCC emissions requirement. (i.e. 200 uV/m, or 46 dBuV/m within a 120 kHz bandwidth). The interfering emissions signals were measured at 3 m from the unlicensed devices, within a 120 kHz bandwidth. The UD interfering emitted signal power level was adjusted to 3 dB below the FCC emission requirement to avoid any impact of measurement error on the measurement results. The generated unlicensed devices interference emission signals were up-converted, filtered and inserted on the desired DTV or NTSC channel. List below is a summary of the relevant parameters and calculations used to conduct these tests:

FCC emission limit: 200 uV/m, or 46 dBuV/m within 120 kHz

Convert to dBm: $P\ (dBm) = -75.5 + 46\ dBuV/m - 20 \log(\text{Frequency in MHz})$

$= -29.5 - 20 \log (\text{Frequency in MHz})$

Interference signal parameters:

- Modulation: 64QAM-OFDM;
- 3-dB bandwidth: 5.57 MHz (wideband), 1.29 MHz (mediumband), 3 x 0.43 MHz, and 0.43 MHz (narrowband)
- Number of OFDM carriers: 5616, 324, 324, and 108;
- Guard interval: 1/16; 64QAM modulation.

***To avoid measurement error, the interference level is set at 3 dB below the FCC specified limit,* thus**:

- For CH-48 (677 MHz), the interference level is –29.5 – 20 log (677) – 3 = –89.1 dBm within 120 kHz.
- For CATV CH-66 (477 MHz), the interference level is –29.5 – 20 log (477) – 3 = –86.1 dBm within 120 kHz. (Note: a CATV NTSC modulator is used in the NTSC system test. CATV and off-air TV have different frequency range, but they all use the same 6 MHz NTSC signal. CATV CH-66 is equivalent to UHF off-air Channel 14 and 15.)

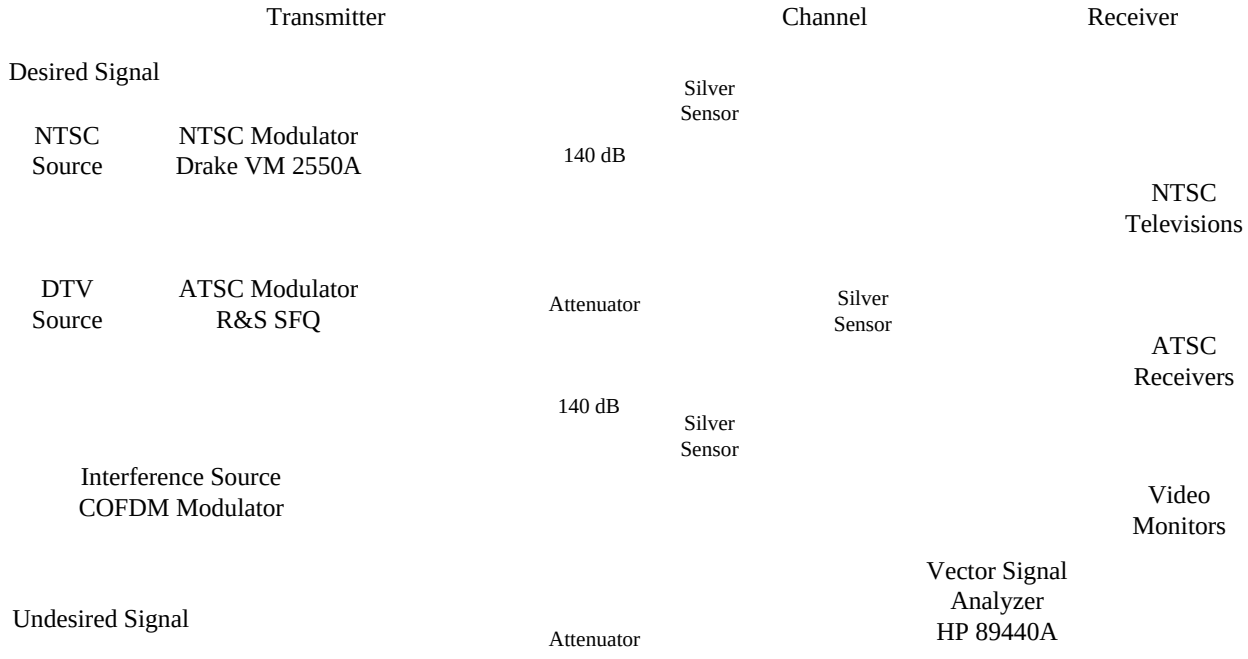


Figure 1 - Laboratory Test Set-up for the Evaluation of UD Emissions Impact on TV Signals.

In the above calculation, a simple dipole antenna is assumed. The emission limit field strength is converted into signal power (dBm). In the laboratory test, the interference power level is

adjusted by varying the transmission power. The receiving power calibration is done at 3m from the emission point for the power levels calculated above.

The laboratory set-up for the evaluation of the ATSC 8-VSB receiver is presented in Figure 1. The set-up is divided into three sections: Transmitter, Channel and Receiver.

The laboratory measurements were conducted for distances between the UD and the DTV receivers of 3 m, 12 m and 24 m; for the NTSC case, the distances were 6 m and 18 m. (Note: Since the NTSC signal is more sensitive to interference, the test points for NTSC system is further away than for the DTV system). Tests were also conducted with the undesired signals transmitted through a wall (typical commercial office dry-wall) and the resulting receiver de-sensitisation measurement recorded. The test procedures are attached (Annex 1).

The Threshold of Visibility (TOV) was recorded for viewing DTV pictures over a 20 seconds period. The ITU-R Grade 3 performance (slightly annoying audio, video, colour) for NTSC was also recorded. The power levels recorded were in 1-dB step-size.

The tests were conducted using one video sequence for DTV and one video test pattern for NTSC (colour bar). The tests investigated the de-sensitisation effects due to UD interference using five different DTV receivers and three different NTSC receivers.

The tests were done on Off-Air Channel 48 (674-680 MHz) for DTV. Since only a cable TV NTSC modulator was available, the NTSC tests were performed in the 474 to 480 MHz band (CATV Channel located in the off-air Channel 14 and 15). All NTSC receivers used in the test have cable ready tuner. There are no over-the-air signals on Channel 14 and 15 in the Ottawa area where the tests were conducted.

As a reference, Figure 2 shows the off-air spectrum plots of 674-680 MHz and 474-480 MHz. It is noteworthy that there is no other interference source detected in these spectrum bands.

Four different UD interference signals were used with a 3 dB bandwidths of 5.6 MHz, 1.3 MHz, 3 x 0.43 MHz and 0.43 MHz. The spectrums of the signals are presented in Figures 3, 4, 5 and 6. Based on the spectrum plots, there is little, if any, multipath distortion at a 3m site.

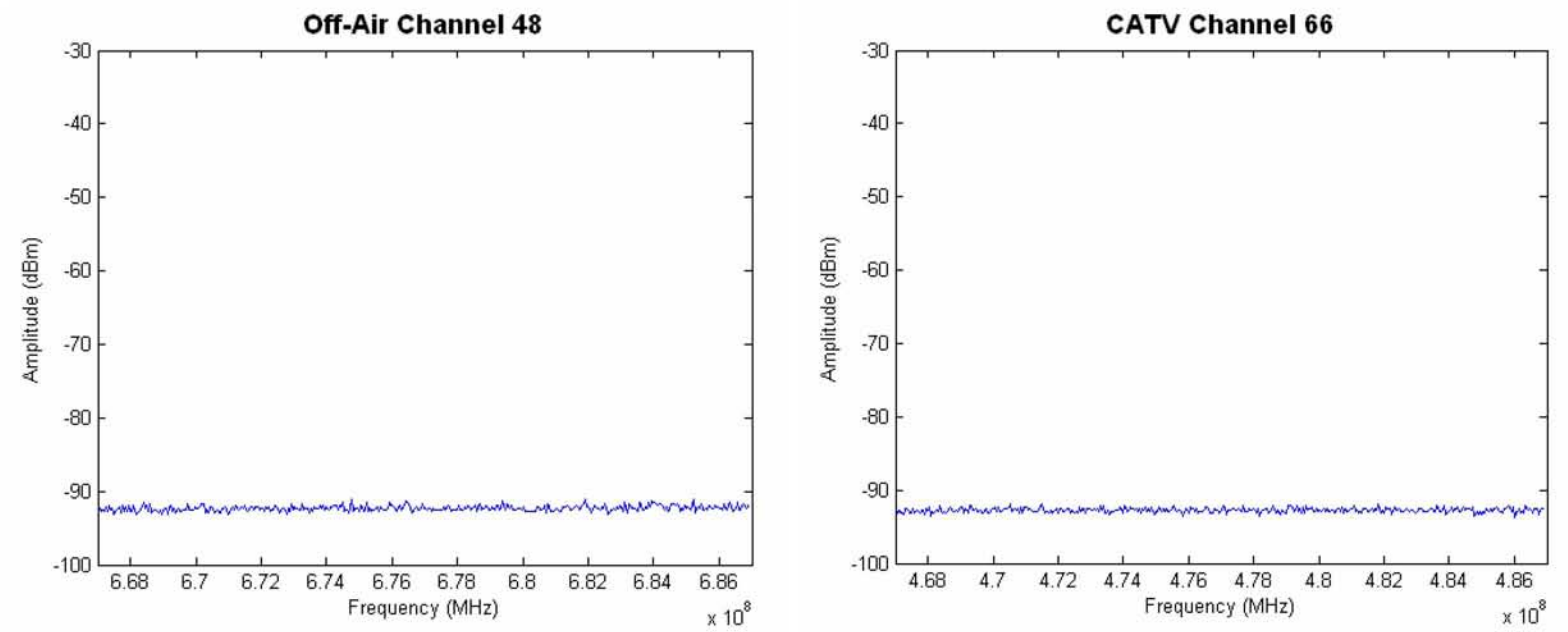


Figure 2. Off-Air Spectrum Plots of 674-680 MHz (DTV Tests) and 474-480 MHz (NTSC Tests)

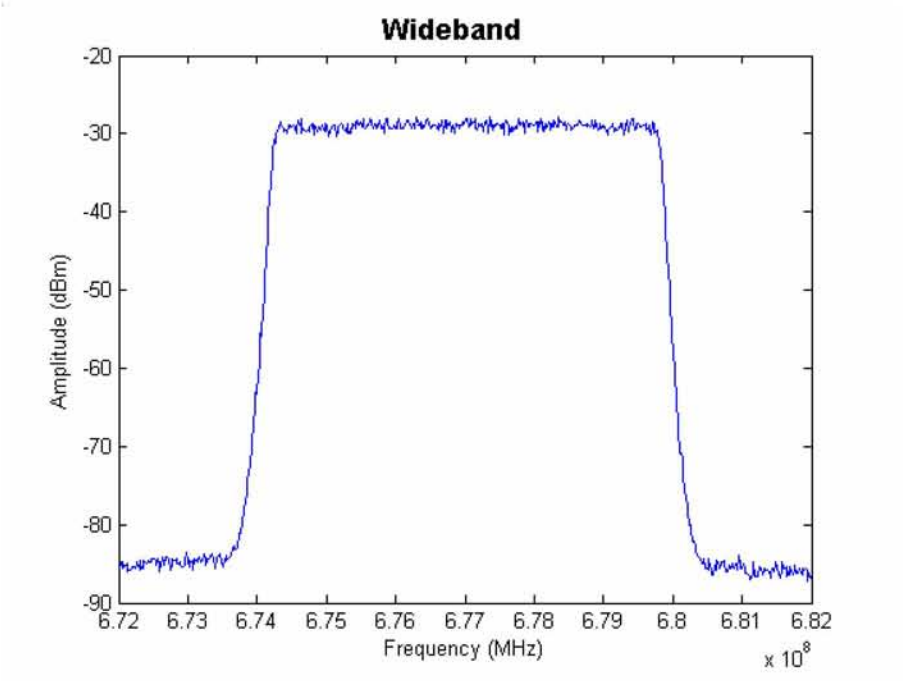


Figure 3. Spectrum of the Wideband Signal with a 3 dB Bandwidth of 5.6 MHz Received at 3 Meters.

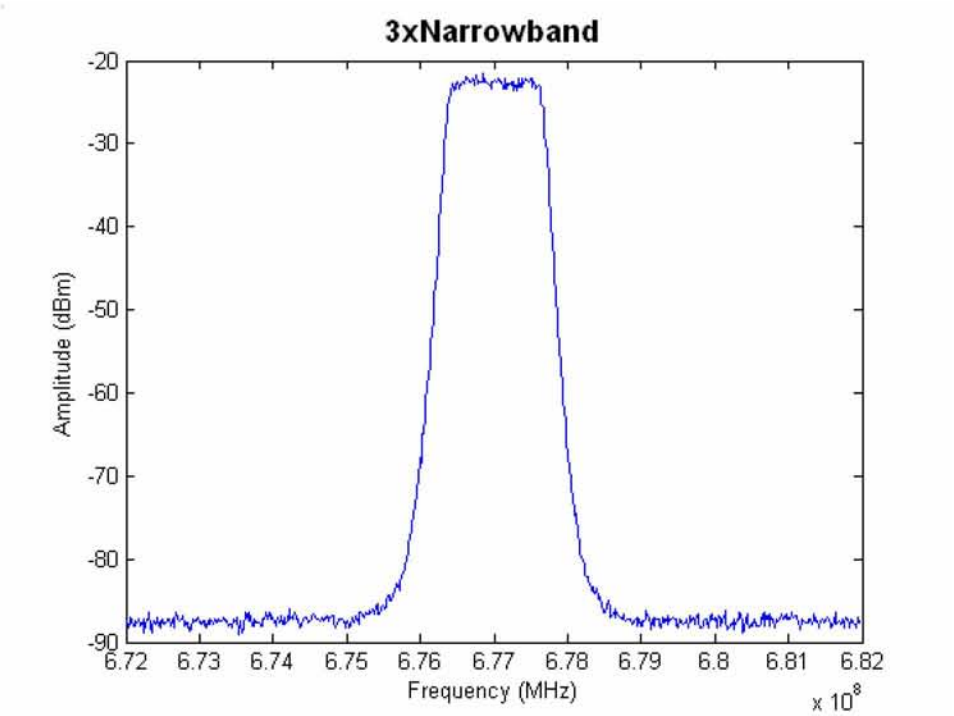


Figure 4. Spectrum of Mediumband Signals with a 3 dB Bandwidth of 1.3 MHz Received at 3 Meters.

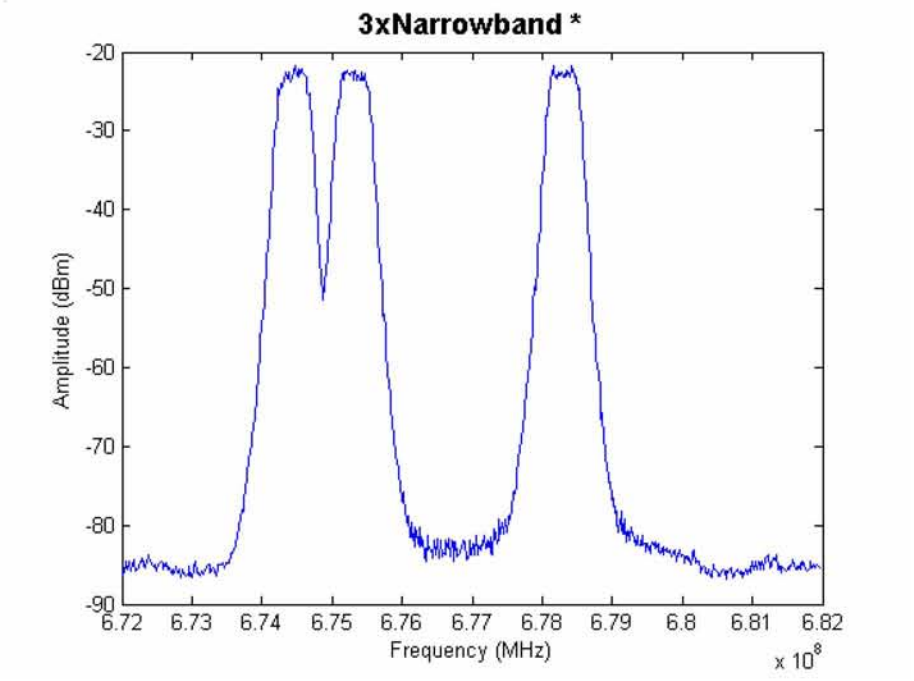


Figure 5. Spectrum of 3 x 0.43 MHz Narrowband Signals Distributed over the DTV Channel Received at 3 Meters.

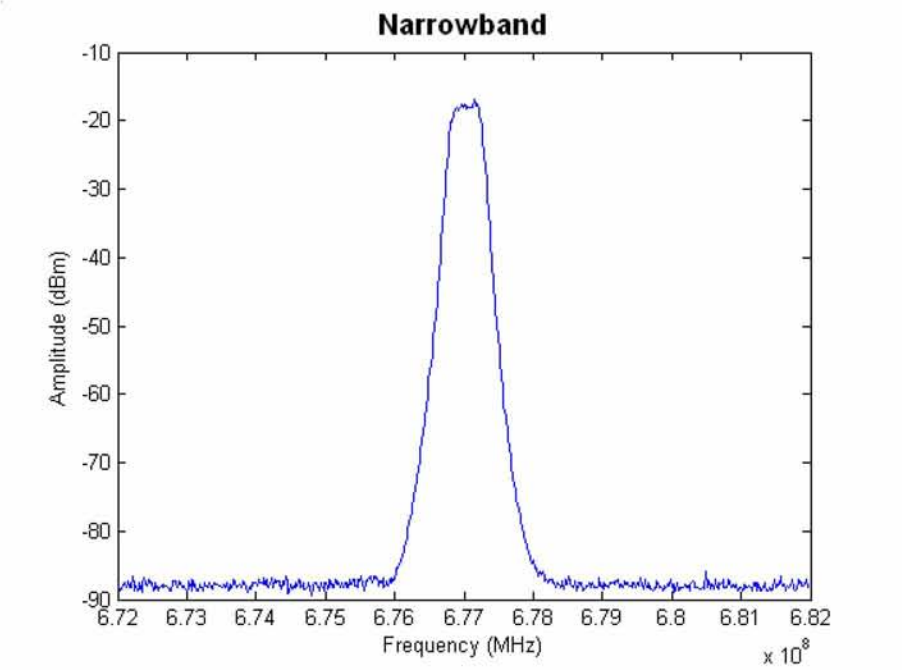


Figure 6. Spectrum of the Narrowband Signal with a 3 dB Bandwidth of 0.43 MHz Received at 3 Meters.

3. Results Of The Laboratory Test

The results of the following laboratory experiments listed below are presented in this section:

- De-sensitisation of DTV receivers in an indoor environment.
- De-sensitisation of DTV receivers with UD sideband signals transmitted through a dry wall.
- De-sensitisation of NTSC receivers in an indoor environment.
- De-sensitisation of NTSC receivers with the narrowband signal transmitted across the NTSC channel.
- Cable ingress created by the UD signals.

3.1 De-Sensitisation of DTV Receivers In An Indoor Environment

The DTV signal and the UD sideband signals were transmitted and received in the same room. The calibration was done at a distance of 3 m from the DTV receiver as specified by the FCC NPRM and explained in the test procedure in Annex 1. The interference signal power was adjusted to obtain -89.1 dBm/120 kHz at 3 meters.

For the 5.6 MHz wideband signal, the total interference power can be calculated as –89.1 + 10 log (5.6/0.12) = -72.4 dBm. For the 1.3 MHz and 3 x 0.43 MHz bandwidth signals, the total interference power is –89.1 + 10 log (1.3/0.12) = -78.8 dBm. For the 0.43 MHz narrow-band signal, the total interference power is –89.1 + 10 log (0.43/0.12) = -83.6 dBm. In all cases, the interference power levels were more than 50 dB below the recommended portable UD indoor power level at 3m reference point.

A total of five DTV receivers were used in these tests.

The tests were conducted on Off-Air channel 48 (674 – 680 MHz). The results are presented in Table 1, 2 and 3 for the tests conducted at 3 m, 12 m and 24 m respectively.

Table 1. De-Sensitisation of DTV Receivers At 3 Meters.

Off-Air Channel 48	DTV Receiver #1	DTV Receiver #2	DTV Receiver #3	DTV Receiver #4	DTV Receiver #5
Rx Sensitivity	-80.5 dBm	-81.0 dBm	-81.9 dBm	-80.6 dBm	-80.1 dBm
		De-sensitisation at 3 meters			
Wideband	24.0 dB	24.3 dB	26.6 dB	24.2 dB	23.7 dB
Mediumband	17.7 dB	18.6 dB	21.7 dB	17.7 dB	16.9 dB
3 x Narrowband*	18.1 dB	18.6 dB	22.5 dB	18.3 dB	17.2 dB
Narrowband	12.7 dB	14.2 dB	17.4 dB	12.7 dB	11.9 dB

*Three 0.43 MHz carriers distributed over the 6 MHz TV channel

Table 2. De-Sensitisation of DTV Receivers At 12 Meters.

Off-Air Channel 48	DTV Receiver #1	DTV Receiver #2	DTV Receiver #3	DTV Receiver #4	DTV Receiver #5
Sensitivity	-81.3 dBm	-82.2 dBm	-84.9 dBm	-82.6 dBm	-85.0 dBm
			De-sensitisation at 12 meters		
Wideband	13.6 dB	14.5 dB	15.8 dB	15.5 dB	16.4 dB
Mediumband	8.8 dB	9.2 dB	13.2 dB	9.6 dB	10.9 dB
3 x Narrowband*	7.4 dB	7.4 dB	11.7 dB	8.7 dB	9.6 dB
Narrowband	3.9 dB	4.9 dB	7.9 dB	4.9 dB	6.4 dB

*Three 0.43 MHz carriers distributed over the 6 MHz TV channel

Table 3. De-Sensitisation of DTV Receivers At 24 Meters.

Off-Air Channel 48	DTV Receiver #1	DTV Receiver #2	DTV Receiver #3	DTV Receiver #4	DTV Receiver #5
Sensitivity	-81.4 dBm	-79.2 dBm	-84.3 dBm	-83.2 dBm	-83.9 dBm
			De-sensitisation at 24 meters		
Wideband	10.4 dB	8.3 dB	14.1 dB	12.1 dB	12.1 dB
Mediumband	6.9 dB	4.7 dB	11.9 dB	8.3 dB	8.9 dB
Narrowband	2.2 dB	1.4 dB	7.2 dB	4.9 dB	4.9 dB

It was noticed that the receiver sensitivity varies in a +/-1 dB range for different test points. This is attributed to one or all of these factors: multipath distortion, noise floor variation and other interference mechanisms. It was also noticed that DTV Receiver #3 always showed a higher de-sensitisation than other DTV receivers. This is attributed to Receiver 3 having a more sensitive tuner and being more susceptible to the multipath distortion (requiring a higher S/N under multipath environment).

It was also observed that signal reflection within the building created standing waves. The result of this phenomenon was that the received signal could be up to 3 dB higher than what it would be for free-space propagation. There were also signal "nulls" in the room, which could result in signal level drops of several dB over small changes in location. Moreover, multipath effects were observed to increase as the distance from the transmitter was increased.

3.2 De-Sensitisation of DTV Receivers by UD Sideband Signals Transmitted Through A Wall.

In these tests, the interference signals were transmitted through one wall before reaching the DTV receivers. The walls are typical interior office fire protective dry wall.

The calibration was done at 3 m as explained in the test procedure in Annex 1. Tests were conducted on Off-Air channel 48 (674 – 680 MHz). The interfering signal power was adjusted to

be at -89.1 dBm/120 kHz at 3 meters from the receivers. The receivers tested using this interference source are listed in Annex 2.

The results of the test using the various DTV receivers each separated from the interference source by one wall such that the DTV receiver was 5 m from the interference source which was 3m from the wall are presented in Table 4.

Table 4. De-Sensitisation of DTV Receivers for Interference Signals Transmitted through One Dry Wall at a Distance of 5 Meters..

Off-Air Channel 48	DTV Receiver #1	DTV Receiver #2	DTV Receiver #3	DTV Receiver #4	DTV Receiver #5
Sensitivity	-80.2 dBm	-81.5 dBm	-82.8 dBm	-80.7 dBm	-82.7 dBm
	De-sensitisation at 5 meters (1 wall)				
Wideband	18.1 dB	19.4 dB	21.6 dB	18.6 dB	20.9 dB
Mediumband	11.6 dB	12.6 dB	15.8 dB	11.9 dB	13.6 dB
Narrowband	7.6 dB	8.8 dB	12.6 dB	7.5 dB	9.1 dB

Similarly, tests were conducted at 12 m the results of which are shown in Table 5. For this case the test were conducted with and without a wall between the interference source and the DTV receivers.

The test results show that the interference signal is attenuated by about 3-6 dB, when going through a typical fire rated office drywall.

Table 5. De-Sensitisation of DTV Receivers for Interference Signals Transmitted and Not Transmitted Through One Dry Wall at a Distance of 12 Meters.

Off-Air Channel 48	DTV Receiver #1	DTV Receiver #2	DTV Receiver #3	DTV Receiver #4	DTV Receiver #5
Sensitivity	-80.8 dBm	-81.1 dBm	-82.4 dBm	-82.0 dBm	-81.1 dBm
	De-sensitisation at 12 meters (No wall)				
Wideband	13.6 dB	14.6 dB	15.8 dB	15.5 dB	16.4 dB
	De-sensitisation at 12 meters (1 wall)				
Wideband	11.3 dB	10.6 dB	13.1 dB	13.1 dB	11.0 dB

3.3 De-Sensitisation of NTSC Receivers in an Indoor Environment

The NTSC and the interference signals were transmitted and received in the same room. The calibration was done at 3m as explained in the test procedure in Annex 1. The interference signal

power was adjusted to obtain -86.1 dBm/120 kHz at 3 meters. The lists of the NTSC receivers used in the tests are also presented in Annex 2.

The de-sensitisation tests were carried out on CATV channel 66 (474 – 480 MHz) equivalent to UHF off-air Channel 14 and 15. (Note: a cable TV NTSC modulator was used in the test, as an off-air NTSC modulator was not available. However, this should have no impact on the test results, since there is only a slight frequency range difference, the signal modulation is the same). The results are presented in Tables 6 and 7 for tests conducted for distance of 6m and 18m respectively. The greater than sign ">" indicates that de-sensitisation was beyond the limits of the test-bed.

Table 6. De-Sensitisation of NTSC Receivers at 6 Meters.

CATV Channel 66	NTSC Receiver #1		NTSC Receiver #2		NTSC Receiver #3	
	TOV	ITU-R Grade 3	TOV	ITU-R Grade 3	TOV	ITU-R Grade 3
Sensitivity	-51.5 dBm	-61.5 dBm	-41.5 dBm	-51.5 dBm	-45.5 dBm	-58.5 dBm
	De-sensitisation at 6 meters					
Wideband	> 23 dB	26 dB	> 13 dB	14 dB	> 17 dB	21 dB
Narrowband	14 dB	15 dB	2 dB	3 dB	14 dB	14 dB

Table 7. De-Sensitisation of NTSC Receivers at 18 Meters.

CATV Channel 66	NTSC Receiver #1		NTSC Receiver #2		NTSC Receiver #3	
	TOV	ITU-R Grade 3	TOV	ITU-R Grade 3	TOV	ITU-R Grade 3
Sensitivity	-51.5 dBm	-61.5 dBm	-41.5 dBm	-51.5 dBm	-45.5 dBm	-58.5 dBm
	De-sensitisation at 18 meters					
Wideband	> 8 dB	18 dB	> 4 dB	12 dB	> 7 dB	16 dB
Narrowband	8 dB	8 dB	2 dB	1 dB	7 dB	8 dB

The test results show that there is more desensitisation for NTSC than that of DTV. This is most likely because the NTSC system requires a higher S/N to operate.

The test also shows that the NTSC Receiver 2 requires 5-10 dB more power (sensitivity) than Receiver 1 and 3 for TOV and ITU-R Grade 3.

3.4 De-Sensitisation of NTSC Receivers with the Narrowband Signal Transmitted Across NTSC Band

The purpose of this test was to study the impact of a narrowband interfering signal positioned at various frequencies across the NTSC channel would have on the NTSC signal itself.

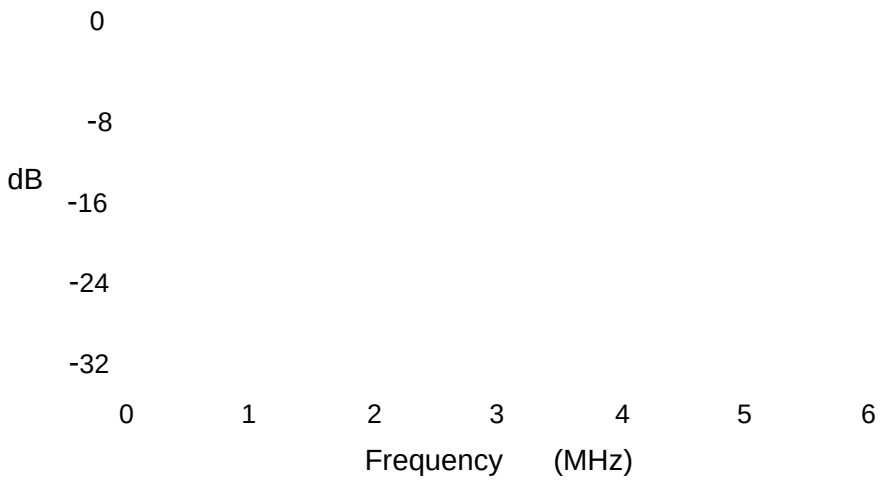
The NTSC signal and the narrowband interference signal were transmitted and received in the same room. The calibration was done at 3m as in previous cases. The interference signal power was then adjusted to obtain -86.1 dBm/120 kHz at 3 meters. The test for this case was completed with only the NTSC receiver #1 (see the list of the NTSC receivers in Annex 2).

Again, CATV Channel 66 (474 – 480 MHz), which is equivalent to UHF off-air Channels 14 and 15, was used for the test. Table 8 presents the test results at 6m and at different frequencies across the NTSC channel. An NTSC visual signal RF subjective weighting curve shown in Figure 7 was used as reference for the interference calculation. Figure 7 shows that the NTSC visual signal is most sensitive to interference positioned between 1.5 and 2.5 MHz above the lower channel edge.

Table 8. De-Sensitisation of NTSC Receivers At 6 Meters For The Narrowband Signal Transmitted Across The NTSC Band

	NTSC Receiver #1				
CATV Channel 66	**Center Frequency of the narrowband interference signal**				
	474.5 MHz (at 0.5 MHz)	**476 MHz (at 2.0 MHz)**	**477 MHz (at 3.0 MHz)**	**478 MHz (at 4.0 MHz)**	**478.75 MHz (at 4.75 MHz)**
	De-sensitisation at 6 meters				
TOV	4 dB	16 dB	14 dB	14 dB	18 dB
ITUR-3	5 dB	18 dB	15 dB	15 dB	18 dB

Figure 7. NTSC Visual Signal RF Subjective Weighting Curve ("S" Curve).



The test results match well with the NTSC visual signal weighting curve ("S" curve), except at the colour sub- carrier location (about 4.75 MHz from the lower channel edge), where it is more sensitive to the interference. This is because the colour-bar test pattern, which is very sensitive to the colour sub-carrier interference, was used for the subjective assessment.

3.5 Cable Ingress Created by the UD Sideband Signals

The purpose of these tests was to determine the possible cable ingress created by the interfering signals.

For these tests, an indoor portable UD was assumed. This UD was set to transmit a 100-mW wideband signal through a Silver Sensor antenna with about 5-dB gain. The closest distance between the antenna and the cable was about 1 meter. Two types of cable were used. One being an RG-6 double shielded cable; and the other an RG-59 single shielded cable. The length of the cable used in the test was about 10 meters. The cable was stretched across a room with one end connected to a Vector signal analyser for ingress signal power measurement. Tests were conducted with the other end of the cable either terminated in its characteristic impedance or un-terminated. The results of the tests are presented in Table 9.

Table 9. Cable Ingress Created by Wideband Emission Signal.

	CABLE INGRESS MEASURED POWER			
	RG-6 CABLE		RG-59 CABLE	
FREQUENCY	**NOT TERMINATED**	**TERMINATED**	**NOT TERMINATED**	**TERMINATED**
195 MHz	-46 dBm	-69 dBm	-44 dBm	-48 dBm
515 MHz	-55 dBm	-68 dBm	-44 dBm	-46 dBm

The results confirmed, as expected, that the double shielded RG-6 cable will pick up interference, if it is not terminated (in our test the un-terminated cable end is about 5m away from the transmitting antenna). RG 6 cable is probably the most widely used cable for home installation of cable TV and Satellite TV systems. For the case of the single shielded RG-59 cable, the test show that regardless of weather it is terminated or not, significant ingress interference was detected. RG 59 is often used by non-professionals to install additional cable outlet at home.

4. Findings & Observations

1. To avoid measurement errors, the interference signal level was set at 3 dB below the FCC recommended emission limit, thus, the actual receiver desensitisation could be up to 3 dB higher than the measurement results.

2. For different interfering signal bandwidth, the results are very much proportional to the interference signal bandwidth. For example, the wideband interference signal, 5.6 MHz BW, will cause 10 log (5.6/0.43) = 11.1 dB more desensitisation than a narrowband interference signal with a 0.43 MHz bandwidth. Test results show that, for each DTV receiver, the discrepancy is within +/- 1 dB over calculated results (see Table 1, 2, and 3). When desensitisation is small as shown in Table 3, the power calculation method is not accurate, since the receiver noise floor will impact the desensitisation. For example, if the interference is at the same level as the receiver noise floor, the desensitisation will be 3 dB rather than 0 dB.

3. It is interesting to note that a 1.3 MHz bandwidth interfering signal has almost the same impact as three individual 0.43 MHz (3 x 0.43 = 1.29 MHz) interference signals (+/- 1 dB accuracy) spread across a TV channel as shown in Tables 1 and 2.

4. Indoor multipath reflection forming standing waves, which results in signal peaks and nulls over few inches distance (RF frequency dependent) were observed. The peak can be 3 dB above free space propagation curve, while nulls can easily cause several dB of signal loss. The further away from the UD, the greater the potential for multipath reflection, which could cause possible desensitisation in extended areas.

5. There was more desensitisation for the case of NTSC than for that of DTV. This result is expected, since the NTSC system requires higher S/N than the DTV system to operate.

6. A narrow band interference signal located in an NTSC channel follows the behaviour of the “S” curve.

ANNEX 1: TEST PROCEDURE

Test Procedure for Unlicensed Devices Interference Signal Emissions into the ATSC DTV and NTSC Channel.

Set Up:

- Select an RF channel between CH14 and 51.
  -Make sure there are minimum off-air interference in co- and first adjacent channels.
- Interference emissions signals:
  1. Wideband emission signal, 5.6 MHz BW
  2. Narrowband emission signal, 0.429 MHz BW
  3. Mediumband emissions signals, 1.3 MHz BW
  4. Three narrowband emissions signals distributed over the 6 MHz channel, 3x0.43 MHz
- Interference signal power level set up:
  - FCC emission requirement: 200 uV/m, or 46 dBuV/m within a 120 kHz BW.
  - Convert to dBm: P(dBm) = -75.5 + dBuV/m – 20 log(Frequency in MHz)
  - The emission signal level should be measured at 3m from the unlicensed devices, within a 120 kHz BW.
  - The signal level should be 3 dB below the above calculated emission level P(dBm) to avoid possible measurement errors. Since allowed interference signal power is calculated and fed to the receiver directly, the type of antenna used for transmission and reception is irrelevant.

- Wanted signal:
  - ATSC DTV and NTSC.
  - TOV is used as the test threshold.
  - Test point: 3m, 12m and 18m away from the unlicensed devices.
  - Tests will also be done with signals transmitted thought a wall.
  - Television channel multipath distortion should be minimum.

DTV TEST

1. Test at 3m with wideband and narrowband interference emissions signals:

- At 3m, measure the off-air interference level (co- and first adjacent-channels), and the equipment noise level in 6 MHz and in 120 kHz bandwidth;
- Adjust interference emission signal power level, measured 3m away, to be P(dBm) – 3 dB over the 120 kHz BW;
- Turn off the interference, transmit ATSC DTV, and find TOV, record the transmitted signal power level in 6 MHz and in 120 kHz bandwidth;
- Turn on the interference emission signal. If DTV reception is not possible, increase the DTV signal power level until TOV, record the DTV Tx signal power level in 6 MHz and 120 kHz bandwidth. The difference between the DTV signal power level with and without the interference emission signal is the receiver de-sensitisation.

2. Test at 12m:

- Keep the interference emission signal power unchanged and moves the test point to 6m.
- Repeat the 3m test.
- The result will be the de-sensitisation at 6m.

3. Test at 24m:

- Keep the interference emission signal power unchanged and moves the test point to 24m,
- Repeat the 3m test.
- The result will be the de-sensitisation at 24m.

NTSC TEST

- Keep the interference emission signal power unchanged, repeat test at 6m, and 18m with NTSC as the wanted signal.
- For narrowband interference test, the interference emission signal should be transmitted at several in-band frequency locations across 6 MHz channel.
- NTSC signal power is measured as peak average power.

ANNEX 2: LIST OF RECEIVERS

DTV Receiver #	Type
1	Consumer
2	Professional
3	Consumer
4	Consumer
5	Consumer

NTSC Receiver #	Type
1	Consumer
2	Consumer
3	Consumer

ANNEX 3: OFFICE DRY WALL AND PHOTOS OF TEST EQUIPMENT

Figure A3-1: Office dry wall Side A (signal goes through white-board).

Figure A3-2: Office dry wall Side B (signal goes through white-board).

Figure A3-3: UD and DTV/NTSC Transmission Systems.

Figure A3-4: Five DTV Receivers and Reception System Set Up.